NASA AUTHORIZATION FOR FISCAL YEAR 1960

HEARINGS

BEFORE THE

NASA AUTHORIZATION SUBCOMMITTEE

OF THE

COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES UNITED STATES SENATE

EIGHTY-SIXTH CONGRESS

FIRST SESSION

ON

S. 1582 and H.R. 7007

BILLS TO AUTHORIZE APPROPRIATIONS TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR SALARIES AND EXPENSES, RESEARCH AND DEVELOPMENT, CONSTRUCTION AND EQUIPMENT, AND FOR OTHER PURPOSES

MAY 21, 1959

PART II

PROGRAM DETAIL FOR FISCAL YEAR 1960

Printed for the use of the Committee on Aeronautical and Space Sciences

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NASA AUTHORIZATION FOR FISCAL YEAR 1960

THURSDAY, MAY 21, 1959

U.S. SENATE,
NASA AUTHORIZATION SUBCOMMITTEE OF THE
COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES,
Washington, D.C.

The subcommittee met, pursuant to recess, at 10:40 a.m., in room 224, Old Senate Office Building, Senator John Stennis presiding.

Present: Senators Stennis, Young of Ohio, Cannon, Smith, and Martin.

Also present: Max Lehrer, assistant staff director; Dr. Glen P. Wilson, chief clerk, and Dr. Earl W. Lindveit, assistant chief clerk.

Senator STENNIS. May we have order, please?

We are glad to have our visitors with us this morning. It is always nice to have an open hearing where the press can be here. The chairman has a very brief opening statement.

This morning we will resume the hearings on the fiscal year 1960 authorization request for the National Aeronautics and Space Administration.

As announced at the outset, consideration of the authorization request was divided into two major phases. The first phase, which involved detailed consideration of the scientific and technical aspects of all important elements of our national aeronautical and space activities currently planned for the next 5 to 10 years, was concluded last month.

The page proofs of these hearings have been placed before each of the members of the subcommittee and it is anticipated that the printed hearings will be available for public release sometime next week. Incidentally, I understand that that is going to be a very important document. We thank you gentlemen for your contribution and I think it will be helpful to the public as well as the Congress.

Today, we shall begin hearings on the second phase of the authorization request; namely, a detailed examination of the specific projects and line items involved in the fiscal year 1960 authorization request of $485,300,000.

Because of the interrelationships between the military and civilian space programs, the NASA authorization request for fiscal year 1960 cannot be considered by itself, but must be considered in conjunction with the concurrent military space programs.

To facilitate such joint consideration, copies of the NASA detailed budget justification books and of the first phase of the hearings on the 1960 authorization have been furnished to the Department of Defense by the subcommittee.

Furthermore, the Secretary of Defense and each of the military departments have been invited to have an observer in attendance at these hearings so that they can provide the subcommittee with their views concerning the relationship of the specific items included in the NASA program to military requirements and to proposed military space programs.

Since NASA witnesses will be expected to testify as to the interrelationship between their programs and the military space programs, the Department of Defense was also requested to make available their detailed budget estimate for the space programs included in the 1960 budget for review by NASA.

This information has just been received by the committee and has been made available to NASA. We shall not go into the military programs today, however, since NASA has not had an opportunity to study all the information provided by the Department of Defense, and there will be more time allowed for this.

In order to complete the record, a copy of the letter of May 7, 1959, to the Secretary of Defense and of Dr. York's reply, dated May 19, 1959, will be inserted in the record at this point, as well as a copy of the unclassified budget justification data for the Advanced Research Projects Agency of the Department of Defense, and a copy of S. 1582.

(The documents referred to above are as follows:)

U.S. SENATE,
COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES,
May 7, 1959.

Hon. NEIL MCELROY,
Secretary of Defense, Washington, D.C.

DEAR MR. SECRETARY: As you will recall, earlier this year I requested you and the Secretaries of the Army, Navy, and Air Force to examine the transcript of the hearings held by this subcommittee on the NASA supplemental authorization for fiscal year 1959, and to advise us whether you agreed with the statements made by the NASA witnesses that there was no present or prospective duplication with any of the armed services with respect to the programs or facilities involved in the supplemental authorization.

In making this request, I stated:

"As you know, Public Law 85–568, which established the National Aeronautics and Space Adiminstration, contains several provisions designed to eliminate duplication in space activities between NASA and the armed services. I know you will agree that we must take every practicable step to prevent the waste of money and scientific and material resources that would be involved in any such duplication."

The Department of Defense responses to this request affirmed that there was no duplication with respect to the specific programs and facilities covered by the supplemental authorization for fiscal year 1959 of $48,354,000. No consideration was given at that time to the programs proposed by NASA and the Department of Defense for fiscal year 1960.

This subcommittee is currently holding hearings on the NASA authorization for fiscal year 1960, which totals $485,300,000. The Administrator of NASA has testified that: "Today, we are making the downpayments on programs that, inevitably, will cost very much more in the years ahead." In view of the large sums involved, the need for careful and detailed review of each of the programs involved in the NASA request for fiscal year 1960 is self-evident.

Because of the interrelationship between the military and civilian space programs, it is necessary for this subcommittee to consider both the military and

civilian aspects in evaluating the NASA authorization request for fiscal year 1960.

Enclosed you will find four copies of the detailed budget justification books presented to the Congress by NASA in support of its fiscal year 1960 request of $485,300,000. As soon as they become available in the next few days, we will also send you four copies of the printed volume covering the first part of this subcommittee's hearings on the NASA 1960 authorization request. These are being sent to you at this time so that there will be ample time for them to be studied carefully by your office and by each of the military departments prior to the initiation of the second phase of the NASA hearings, tentatively scheduled for May 19, 1959.

The subcommittee invites you and each of the military departments to have an observer in attendance at these hearings, since your views, and those of the military departments, will be desired concerning the relationship of the specific items included in the NASA program to military requirements and to proposed military space programs.

Since NASA witnesses will also be expected to testify as to the interrelationship between their programs and the military space programs, it is requested that this subcommittee be given four copies of all budget justification material covering the military space programs for fiscal year 1960. We would also appreciate receiving four copies of the firm military space program for the next 6 years, concerning which Mr. Roy Johnson recently testified before the Subcommittee on Governmental Organization for Space Activities.

Your cooperation in this matter is greatly appreciated.

Sincerely yours,

JOHN STENNIS,
Chairman, NASA Authorization Subcommittee.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., May 19, 1959.

Hon. JOHN STENNIS,
U.S. Senate.

DEAR SENATOR STENNIS: Secretary McElroy has asked me to reply to your letter of May 7, 1959. Accordingly, I am forwarding as inclosures, (1) four copies of a document entitled "Congressional Presentation—Advanced Research Plan" which has been prepared by the Director of the Advanced Research Projects Agency, and (2) four copies of the "General Justification for the Budget Estimates for the Advanced Research Projects Agency for Fiscal Year 1960." Inclosure (1) should not be considered a "firm military space program" but rather a projection of military space program planning which serves to indicate the possibilities that could be realized over the next 8 years, if it is determined that these programs should be pursued after consideration of our total defense requirements.

The military departments and the Advanced Research Projects Agency have carefully reviewed the proposed NASA Authorization Program for fiscal year 1960. On the basis of the results of this review I am confident that there is no unnecessary duplication between the space program of the NASA and the Department of Defense. The broad program areas have all been coordinated thoroughly and I believe are mutually complementary. Within the broad program areas, however, there may be supporting tasks or projects that follow similar lines of endeavor, since the techniques and equipment developments in certain cases are common to both scientific and military space vehicles.

In this connection, the Administrator, NASA, and the Director, ARPA, have initiated the formation of permanent joint committees to make continuing evaluations of the programs and projects that are being conducted by both NASA and ARPA. Through this joint review which is now underway I feel certain that any unwarranted duplication that may be revealed can be quickly eliminated.

Sincerely yours,

HERBERT F. YORK.

DEPARTMENT OF DEFENSE—ADVANCED RESEARCH PROJECTS AGENCY

BUDGET ESTIMATES FOR SALARIES AND EXPENSES, ADVANCED RESEARCH PROJECTS AGENCY, FISCAL YEAR 1960

GENERAL JUSTIFICATION

APPROPRIATION LANGUAGE

"SALARIES AND EXPENSES, ADVANCED RESEARCH PROJECTS AGENCY, DEPARTMENT OF DEFENSE

"[SALARIES AND EXPENSES]

"For expenses necessary for such advanced research projects as may be designated and determined by the Secretary of Defense[, $520,000,000] *pursuant to law, $455,000,000,* to remain available until expended: *Provided,* That such amounts as may be determined by the Secretary of Defense to have been made available for related programs in other appropriations available to the Department of Defense during the current fiscal year may be transferred to and merged with this appropriation to be available for the same purposes and time period: *Provided further,* That such amounts of this appropriation as may be determined by the Secretary of Defense may be transferred to carry out the purposes of advanced research to those appropriations for military functions under the Department of Defenes which are being utilized for related programs, to be merged with and to be available for the same time period as the appropriation to which transfered. (*Department of Defense Appropriation Act, 1959.*)

Appropriated 1959, $520,000,000 Estimate 1960, $455,000,000
Appropriated (adjusted) $399,742,000

APPROPRIATION INTRODUCTION

Salaries and expenses, Advanced Research Projects Agency, Department of Defense

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960
Appropriation or estimate		$520,000,000	$455,000,000
Adjustments by transfers	$83,100,000	−120,258,000	
Unobligated balance brought forward		67,583,806	39,999,806
Unobligated balance carried forward	−67,583,806	−39,999,806	−39,999,806
Total obligations	15,516,194	427,326,000	455,000,000

This appropriation provides for the Advanced Research Projects Agency which is responsible to the Secretary of Defense for the planning, development, administration, and management of the various programs assigned. ARPA is the primary sponsor of military astronautics programs directed toward the improvement of space technology for military purposes and the investigation of specific military application of space vehicles. ARPA is also conducting research and development related to such specific applications of military interest as reconnaissance, communications, navigation, and early warning of ballistic-missile attack.

PURPOSE AND SCOPE OF THE APPROPRIATION

The current research and development program of the Advanced Research Projects Agency is concerned primarily with the application of space technology to military problems, with the investigation of improved methods of defense against ballistic missiles, and with propellant chemistry. Work may also be assigned to the Agency in other areas.

1. *Military science.*—Research in solid-propellant chemistry. The objective is the discovery of new chemicals, the development of practical methods of synthesis, and the knowledge required to utilize these materials in highly efficient solid propellants. The initial goal is to achieve a 10–20 percent increase in specific impulse over solid propellants now under development.

2. *Missiles and related equipment.*—To achieve improved missile defense, research in the nature of the threat, identification, and discrimination techniques, kill mechanisms, and data systems. The objective is to identify advanced techniques for missile defense that will be technically, operationally, and economically feasible.

3. *Military astronautics and related equipment.*—Studies, development, tests, and launchings of early warning, communications, and navigation satellites, and their components. In addition, development of the clustered booster, reconaissance systems, and exploratory development leading to the application of advanced technology to specific military problems.

4. *Programwide management.*—Executive and technical management at ARPA headquarters.

Summary of program by category

	Estimated obligations	
	Fiscal year 1959	Fiscal year 1960
Military sciences: Solid-propellant chemistry	$13,700,000	$18,000,000
Missiles and related equipment:		
Ballistic missile defense:		
1. Missile-flight phenomena	25,000,000	44,650,000
2. Missile and satellite identification and kill	10,000,000	17,600,000
3. Missile acquisition, tracking, and data reduction	23,000,000	35,250,000
4. Feasibility investigations and exploratory research	22,000,000	30,600,000
Subtotal	80,000,000	128,100,000
Astronautics and related equipment:		
Military space technology:		
1. Sentry	95,000,000	100,000,000
2. Communications	15,000,000	40,000,000
3. Precision navigation	4,500,000	12,000,000
4. Very early warning	12,000,000	18,000,000
5. Cloud-cover surveillance	10,000,000	----------
6. Manned satellite	8,000,000	----------
7. Discoverer	100,000,000	60,000,000
8. High-energy upper stage	15,000,000	----------
9. Clustered engine booster	19,000,000	50,000,000
10. Tracking and data acquisition	17,000,000	17,000,000
11. Feasibility investigations and exploratory research	13,441,337	10,000,000
12. Scientific space investigations	22,784,663	----------
Subtotal	331,726,000	307,000,000
Programwide management and support: Executive and technical direction	1,900,000	1,900,000
Total program	427,326,000	455,000,000

Explanation of Estimates, Fiscal Year 1960

INTRODUCTION

The programs of the Advanced Research Projects Agency are summarized in the following categories:

Military sciences solid-propellant chemistry.

Missile and related equipment, missile defense.

Astronautics and related equipment, military space technology.

Programwide management and support, executive and technical direction.

The technical programs have been assigned to ARPA by the Secretary of Defense, and the budget estimates have been developed to meet necessary national defense goals in these areas.

PROGRAM AUTHORITY

The Advanced Research Projects Agency was established by DOD Directive 5105.15, February 7, 1958. This directive states that "the agency shall be responsible for the direction or performance of such advanced projects in the field of research and development as the Secretary of Defense shall, from time to time, designate by individual project or by category."

DOD Directive 3200.5 established a procedure for the actual assignment of projects to ARPA.

Section 7, Public Law 85-325, dated February 12, 1958, as amended by the Department of Defense Reorganization Act of 1958, essentially endorsed the concept of special consideration being given to certain research areas by providing "the Secretary of Defense or his designee is authorized to engage in such advanced projects essential to the Defense Department's responsibilities in the field of basic and applied research and development which pertain to weapon systems and military requirements as the Secretary of Defense may determine. * * * The Secretary of Defense shall assign any weapons systems developed to such military department or departments for production and operational control as he may determine."

The National Aeronautics and Space Act of 1958 provides, in part, "that activities [aeronautics and space] peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense. * * *"

ARPA OPERATIONS

ARPA was established as a line agency within the Department of Defense. Within program areas assigned by the Secretary, ARPA plans, initiates, and directs specific projects. It performs its responsibilities by directing and funding the work. ARPA has no laboratory operations of its own. It is a small management organization, assisted in the technical aspects of its work by the Institute for Defense Analyses, which, under contract, recommends technical programs and is available for consultation on technical matters.

CLASSIFIED INFORMATION

Additional details of a classified nature pertaining to the ARPA programs described in this justification will be provided in supplementary material.

Military sciences

Solid propellant chemistry:

Fiscal year 1959	$13,700,000
Fiscal year 1960	$18,000,000

Solid propellants now available are not high enough in performance to allow optimum design of ballistic missiles, ballistic-missile defense systems, and other guided missile and space systems. The overall objective of this program is the discovery of new chemicals, and development of practical methods of synthesis and the knowledge required to utilize these materials in highly efficient solid propellants. A major aspect of this objective is also the supporting research necessary to make effective use of these high-energy materials and propellants when they become available. The initial objective is to make available for developmental applications solid propellants and the techniques for using them having specific impulses at least 10 to 20 percent higher than other propellants now under development.

The availability of such advanced propellants would greatly increase the capabilities of ballistic-type weapons so that significant increases in range and payload or corresponding reductions in weight and volume of the system can be achieved. The availability of such improved performance propellent propulsion systems are of critical importance to the ballistic-missile and ballistic-missile-defense programs. The availability of such improved propellant systems would also be of major significance to all the guided-missile programs of the Department of Defense. The possibility of use of such systems in the space program, particularly initial boost phases for launching statellites and space vehicles, is also attractive.

Missiles and related equipment

	Fiscal year 1959	Fiscal year 1960
Ballistic-missile defense:		
1. Missile-flight phenomena	$25,000,000	$44,650,000
2. Missile and satellite identification and kill	10,000,000	17,600,000
3. Missile acquisition, tracking, and data reduction	23,000,000	35,250,000
4. Feasibility investigations and exploratory research	22,000,000	30,600,000
Total	80,000,000	128,100,000

The threat posed by an enemy ballistic-missile complex which is fully operational is of such a nature that conventional concepts of active defense are inadequate to cope with it. Such concepts reach a practicable limit of technical sophistication in the developing Nike-Zeus system of active terminal defense. Before a fully adequate and effective defense can be designed, however, considerably more is needed. The advanced defense must be highly effective in dealing with attempted attacks by ICBM's and IRBM's in all their possible variety and in a technologically developing environment. It must be technically, operationally, and economically feasible and should be achieved with all possible deliberate speed.

The ARPA research program is calculated to fullfill these needs as rapidly, completely, and economically as possible. It has three major facets:

First, advanced defense complexes which meet operational and technical feasibility standards and which employ well-known principles can be predicted at this time only in outline. The detailed knowledge requisite to high-confidence design is still lacking. The ARPA program is carefully constructed to obtain the necessary detailed understanding from research on a number of fundamental questions concerning the nature of the threat, means for detection, acquisition, and tracking of missiles, and methods of identification and kill. Considerable emphasis is given to obtaining improvements in the state of several essential arts.

Second, the costs of defense, which bear generally a close relationship to the total effectiveness desired, may be exceedingly high. Because of this important economic factor, the advanced defense complex finally selected for development must represent a reasonable optimum among all possible choices. The ARPA program includes conceptual and feasibility investigations which will throw light on the nature of such an optimum complex and demonstrate its advantages.

Finally, it is just possible that unpredictable advances of more-than-usual value or stature may greatly simplify the task of defense. The ARPA program of exploratory research and techniques development is designed to encourage this possibility to a practical maximum.

Nature of threat.—The threat as visualized by ARPA includes all the methods by which ballistic missiles and satellites may be employed to attack the continental United States and adjacent territories. The time period considered in present planning begins essentially now. Some features of the threat are clearly earlier than others, but all should be available within the next 10 years. Beyond this period, the threat can be expected to become even more varied and severe as a natural consequence of technological progress.

Ballistic missiles are defined as those missiles whose payloads over the greater portion of their flight path are traveling on a ballistic trajectory, the nature of which is determined by the laws of dynamics. Most generally, such trajectories are Keplerian or elliptical orbits which intersect the earth at two points. Of concern are short- and intermediate-range ballistic missiles which can be launched from surface or submarine vessels or aircraft, and ballistic missiles of intercontinental range. Other missile threats are possible, but may reasonably be expected to exhibit a greater vulnerability to an advanced defense complex than ballistic missiles themselves.

A ballistic missile is placed on an appropriate trajectory by the guided thrust of high-power rocket engines which develop the velocity needed by the payload to attain a desired range. For moderate to intercontinental ranges, the velocity is very great, being about 15,000 feet per second for 1,500 miles range and about 23,000 feet per second for 6,000 miles range. Missile attacks may exhibit a wide range of elevation angles and velocities with somewhat greater probability attached to trajectories which optimize payload delivery.

Considering its great energy, the ballistic-missile payload must be very tough to get back through the atmosphere. Reentry bodies of a size to deliver H-bombs of various yields can be delivered.

The elementary features of the threat (i.e., the nature of the reentry body itself) as it appears to a defense system are three:

High average velocity, short reaction time;
Compact and smooth, difficult to detect;
Extremely tough, difficult to destroy.

Conventional defense systems, i.e., those employing radar and intercepting missiles can be built to give a high probability of kill if the attack consists of a small number of identified warhead-containing reentry bodies within their zone of action. Nike-Zeus will have a capability to deal with such simple threats even

though attacks are complicated by fragments of the rocket-propulsion system which necessarily accompany the reentry body.

On the other hand, ballistic missiles deliver payload or tonnage which is at the offense designer's option to divide in a variety of ways. If the defense system is expected to be highly effective against a simple form of attack, the offense will trade yield for countermeasures such as decoys and jammers to take advantage of the natural weaknesses of defense systems and reduce the system effectiveness. The offense purpose, of course, is to maximize the yield (or desired effect) on target either by saturating, confusing, or avoiding the defense system. Some feasible and suitable divisions of payload are given below:

WARHEAD-CONTAINING REENTRY BODIES

Simple or staged: The body may enter smoothly or be provided with separable drag skirts and so exhibit a very erratic atmospheric flight path.

Unshielded or shielded: Some of the yield may be traded for radiation shielding to reduce vulnerability.

Normal or artificial cross-section: The body may be coated with radar-absorbent material to reduce all radar ranges outside of the atmosphere.

Single or multiple: The payload may be divided into a number of small warhead-bearing, reentry bodies.

Decoys.—Radar is a surface- or length-measuring device. Decoys are designed to simulate possible reentry bodies under various conditions. In addition to especially designed decoys, the natural tankage, etc., associated with rocket propulsion systems provides a large number of radar decoys.

Free-space replicas: Very light weight objects which simulate the reentry body.

Reentry decoys: Objects of considerably greater weight which behave during reentry like warhead-containing bodies.

Combined: It may be possible by advanced techniques to make low-weight objects which simulate reentry bodies both in and beyond the atmosphere.

Chaff: Simple chaff may be used.

Jammers.—Radar is sensitive and is therefore vulnerable to jamming by small active barrage or spot jammers and repeaters, particularly at great ranges.

All such payload divisions, in response to an effective defense system, result in lower total yields delivered above a target but are calculated to result in higher total damage on the target. It should be noted also that multiple missile attacks against given targets will probably be the rule, opening up the possible use of missiles which deliver countermeasures alone.

In the light of the above discussion, it is evident that the defense system may be forced to deal with objects whose behavior is exceedingly complex and erratic, which may appear in great numbers, and which may embody large quantities of warheads. Finally, if indirect effects against populations, such as massive fallout or high-altitude thermal radiation, are employed, the threatening objects will not necessarily ever be within reach of defense systems of purely local capability.

It is the consensus of technical judgment that the attack variations noted, as well as others not discussed, are possible in reasonable future time periods and that therefore the advanced defense complex must comprise elements with an overall capability against the spectrum of the threat.

Major technical concepts.—In view of the potential variety of the threat, a prime objective of defense design is to make the ballistic missile attack in strategic war as expensive and uncertain as possible for the least cost to defense.

A few major concepts have evolved and are under study.

Discrimination techniques try to reject objects which are not warhead-containing reentry bodies or which cannot apparently impact within forbidden areas.

Identification techniques try to positively identify warheads, either by their necessary content, by locating them within a known volume smaller than the confused volume, or by other means.

Combined passive and active defenses: Although passive defense is not the business of ARPA, it is clearly simpler to defend small, hard or dispersed targets than big, soft targets. A greater number of methods are appropriate and the cost for a given effectiveness is much less. An example is to be found in the defense of hardened ICBM missile sites by very low altitude terminal defense systems. This concept is quite well understood but additional worthwhile methods of defense need examination and should be studied.

Very early warning.—Only in the area of very early warning against ballistic-missile attack by an enemy do missile defense activities contribute directly to the

strength of our retaliatory capability and to the ability of our people to survive by seeking shelter. Benefits of this sort exist independently of the effectiveness of the active missile defense to which very early warning also contributes.

There are other concepts, less well-defined, which also need further work and are considered in the ARPA programs.

The consensus of technical judgment is that the threat is potentially so varied that the advanced defense complex most probably must exploit several major concepts in its structure. It must also embody a considerable firepower capability to deal with real threatening objects in large numbers.

1. Missile flight phenomena:

Fiscal year 1959	$25,000,000
Fiscal year 1960	44,650,000

It is the purpose of the antiballistic missile effort to prevent damage to the intended target of a ballistic missile. It is firm assumption that action to destroy ballistic missiles will be taken initially only after such missiles are seen to be in a threatening trajectory. The defensive system, therefore, must be capable of suitable reaction solely on the basis of information gathered during the actual flight of a ballistic missile. It is therefore a requirement that complete experimental information on our own developmental missiles be gathered on those characteristics of ballistic missile flight which will enhance or limit the capability of a defensive system to identify, track, and kill the ballistic missile.

Ground-based measurements are emphasized in this program since they can be most completely and inexpensively performed. Shipboard measurements are required, in view of the limited land masses available on or near the projected ground path of the missile. Airborne measurements are needed in order to observe infrared and optical phenomena with minimum confusing effects from the earth's atmosphere at lower levels. Special range facilities will be required in some cases in order to overcome some of the limitations of developmental ballistic missile programs from affecting in all respects the observations and tests of antiballistic efforts. Supplementary theoretical and laboratory support will be provided to improve the interpretation of the results of the range measurement programs.

2. Missile and satellite identification and kill:

Fiscal year 1959	$10,000,000
Fiscal year 1960	17,600,000

This category provides for a variety of research studies which will generate essential data for use in developing advance discrimination and defense systems against inimical ballistic missiles and satellites.

Ballistic missiles and satellites have characteristics which make them difficult to intercept and destroy because they operate outside the atmosphere. The prime difficulty is that any objects which are ejected from a missile (or a satellite) with a small ejection velocity will travel right along with it because of the absence of atmospheric drag. It is thus possible to generate large clouds of objects surrounding, or displaced from, such missiles or satellites, but having the same general trajectory or orbit characteristics as the dangerous object to be intercepted. The problem of identification of the true warhead (or satellite) then becomes of great importance to the defense. No single method has yet been suggested which will permit positive identification under all circumstances. It thus becomes necessary to depend on combinations of methods and on elaborate correlation and computation schemes in order to have any hope of performing a sorting operation with confidence.

Once the object to be destroyed has been identified, its destruction may still constitute a serious problem. Because it has to reenter the atmosphere and because it needs no wings nor similar weak structure, the warhead reentry body of a ballistic missile is generally tough and can be destroyed only by extreme measures. It is true that satellites are not likely to be quite so tough unless they are designated for reentry. On the other hand, the interception of satellites presents other difficulties such as their greater height.

3. Missile acquisition, tracking, and data reduction:

Fiscal year 1959	$23,000,000
Fiscal year 1960	35,250,000

A very large part of the business of active defense against attacking ballistic missiles or satellites is the task of acquisition and tracking of these difficult

targets through equipment able to provide fast and accurate information on their locations, characteristics and trajectories. Radar remains the strong tool for acquisition and tracking and must be advanced to the utmost. Radar development objectives, which dominate this program, are to attain extremely high power, resolution, precision and data rate, in order to meet more nearly the heavy requirements of active defense against missiles.

Another major area of study in this category is that of fast, automatic reduction of masses of incoming data, to permit unerring assignment and control of weapons for active defense, together with the related tasks of maintaining and controlling communication of data throughout a farflung defense system, and of displaying reduced data to human monitors and receiving from them control based on their judgment.

4. Feasibility investigations and exploratory research:

Fiscal year 1959	$22,000,000
Fiscal year 1960	30,600,000

To fulfill its mission of conducting that advanced research necessary to guarantee U.S. military superiority, ARPA must examine and test the feasibility of concepts, equipment, and proposals (many of them unconventional) which may come forth unattached to any developmental systems designs. ARPA must generate new ideas and novel techniques which appear to hold promise of significantly improving and magnifying American defense and offensive capabilities with regard to ballistic missile attacks.

Essentially these investigations and research projects will be looking for major breakthroughs rather than simply refining existing techniques and equipment. They will constitute "advanced research" in the most liberal meaning of the term. All aspects of missile defense will be reviewed including the vehicles, detection equipment, data transmission and handling techniques, the physical properties of materials, guidance and control equipment, and the mean for exercising positive military command over weapons systems of the future. Identification of inimical military space vehicles and the development of unconventional kill mechanisms will naturally be an important objective in this type of investigation.

Astronautics and related equipment

	Fiscal year 1959	Fiscal year 1960
Military space technology:		
1. Sentry	$95,000,000	$100,000,000
2. Communications	15,000,000	40,000,000
3. Precision navigation	4,500,000	12,000,000
4. Very early warning	12,000,000	18,000,000
5. Cloud cover surveillance	10,000,000	----------
6. Manned satellite	8,000,000	----------
7. Discoverer	100,000,000	60,000,000
8. High-energy upper stage	15,000,000	----------
9. Clustered engine booster	19,000,000	50,000,000
10. Tracking and data acquisition	17,000,000	17,000,000
11. Feasibility investigations and exploratory research	13,441,337	10,000,000
12. Scientific space investigations	22,784,663	----------
Total	331,726,000	307,000,000

The U.S.S.R. has surpassed the United States in technological accomplishments in outer space. The U.S.S.R., if it long maintains its present superiority in the exploitation of outer space, will be able to use that superiority as a means of undermining the prestige and leadership of the United States and of threatening U.S. security.

It is the responsibility of the DOD to undertake all reasonable steps to checkmate any threat to U.S. security.

The programs here presented have all been initiated in fiscal year 1959, and are aimed at those uses of space for military purposes that have advantages over other solutions to the problems. It is necessary in the planning of a military program in space to fully realize that space is a region (or, a place) rather than a thing. This means that space must be considered as complementary and analogous to the atmosphere, the ocean, or to the surface of the earth. We can further conclude that many of the things we can do on the surface of the earth, for example, or in the ocean, we can do in space. Some things can be done in

space that cannot be done elsewhere. Thus, it is immediately apparent that only those things which can best be done in space should be in a space program. Or, alternately, that the degree to which they are done in space must be rational in respect to the degree of advantage achieved.

In military reconnaissance, broadly speaking, the several alternatives are observation directly at ground level, observation by aircraft or, finally, observation by space vehicles. It is immediately obvious that each location has certain advantages and certain penalties. Ground level reconnaissance will provide exceedingly detailed and exacting information but it is frequently impossible of access and is always laborious to perform. Aircraft relieves the difficulty of access but introduces errors and hazards. Satellites still further ease access but also make more serious certain problems. By careful consideration of problems and results we may conclude that military reconnaissance by satellite does offer a new degree of freedom of access but exacts the penalty of extreme precision and great sophistication of equipment. The reward consists of a priceless flow of visual and electronic information relating to the surface activities of any region of interest.

In communication a trade-off exists between earthbound systems and satellite systems. Again priceless results are available from a satellite system but only at the penalty of exacting and difficult performance. For example, the satellite communication system of ultimate interest involves the use of a satellite of several thousands of pounds weight in an orbit at 2,200 miles. This requires booster vehicle performance well beyond our current capability. We must therefore engage in the development of carrier vehicles capable of an order of magnitude (or more) greater payload capacity. The rewards—all weather communications, doubling of the present global message capacity, and jam-free command links—are very compelling and fully justify the effort.

Navigational aids to ships at sea, missile-carrying submarines and aircraft can readily be provided by orbital equipment.

Ground-based early-warning radars give considerably less than the maximum warning of ICBM attack. Warning techniques which detect ballistic missiles during launching are necessary to obtain maximum warning for alerting retaliatory forces, active defense, and the civil defense. The tremendous flame of a large missile booster or sustainer rocket is found to permit very sure detection of missile launching at very long distances, with the aid of infrared sensing devices located at high altitudes. Satellite-borne infrared early warning systems are very promising and should be developed quickly; it is possible that development of an interim airborne system will also prove advisable.

Weather data and predictions on a global basis for military operations can be greatly improved with satellite systems.

To reach the desired effectiveness in any of the military space technology programs, there must be a vehicle development program that will result in steady growth of payload capability. It is this requirement for ever larger engines that underlies the theme of the military usefulness of space as a place. A significant part of this program is, therefore, devoted to improved engines and vehicles which will permit larger payloads, and/or higher orbits in the future.

1. Sentry:

Fiscal year 1959	$95,000,000
Fiscal year 1960	100,000,000

The Sentry reconnaissance system provided by this development program is designed to fulfill requirements vital to the defense of the United States. In order to provide timely military information vital to defense planning, an orbiting satellite reconnaissance system could be employed to provide at a reasonably early date surveillance of the complex of a potential enemy.

The Sentry reconnaissance system is composed of the satellite vehicle, the booster, launch facilities, tracking facilities, and a complex communication and data processing network with related facilities.

The satellite-borne advanced reconnaissance development program is divided into two parts:

ENGINEERING PROTOTYPE TESTS

Subsystems development

The major activity of this program is concerned with the design, fabrication, and laboratory evaluation of experimental and prototype models of observation subsystems. Such work includes extensive environmental testing of the prototype and determining compatibility with the ground-based systems. Extensive

testing will have to be performed to obtain the reliability required for long life unattended operation.

2. Communications:

Fiscal year 1959	$15,000,000
Fiscal year 1960	40,000,000

This project has the objective of developing new communications systems required by the military services. Communication planning studies conducted by the armed services indicate that the continually rising demand for intercontinental electric communications to support our Armed Forces is likely to saturate the capability of conventional systems within the decade. Communications with aircraft for navigational purposes, operational information, and even military strike commands will be greatly improved if a system of communication can be devised which is independent of weather, global location, and enemy jamming action. There is a similar urgent need for communication with fleet ballistic-missile submarines.

New modes of global communication will be intensively examined. The use of space satellites as repeater devices appears to be most promising and must be further explored immediately.

Communication methods with satellites may be resolved into real-time repeater communication and delayed-repeater communication. Both methods involve many parameters including height of orbit (up to and including the stationary satellite orbit), cryptographic devices as necessary for security, auxiliary power supplies, stability of orientation, and reliability. A satellite communications system using the stationary satellite orbit and having suitable numbers of units with proper frequencies and radiated power could provide for increased communication capability amounting to a major fraction of the present total global communications capability. Thus, the economic and security value of these systems are of greatest importance.

Design of the electronics equipment will require intensive development and life testing to provide the maximum in broadband capacity and at the same time to meet the need for absolute reliability in the space environment for periods of time measured in years. Other significant requirements which crowd the present state of the art are light weight, low power consumption, and antijamming capability.

3. Precision navigation:

Fiscal year 1959	$4,500,000
Fiscal year 1960	12,000,000

Many critical military operations—launching of ballistic missiles from submarines, the initiation of changes in missile inflight trajectories, for example, demand exact knowledge of location or position. Satellites, by virtue of the stability and predictability of their orbits, have a potential as global all-weather aids to navigation. By incorporation of a radio transmitter, they can emit a signal by which observing stations (ships, submarines, or aircraft) can determine their position using Doppler techniques. Use of this satellite-emitted signal has the advantage of enabling units to learn their exact position. This program will explore the feasibility of the navigational concept.

The initial investigation of precision navigation aids has been started in fiscal year 1959 by initiation of a study of Doppler navigational systems. A relatively simple transponder with coded output will be used in this phase.

4. Very early warning:

Fiscal year 1959	$12,000,000
Fiscal year 1960	18,000,000

Work in this area provides for investigations and studies of means for giving very early warning by observation and interpretation of scientific phenomena directly associated with the launching and early flight of attacking missiles as distinguished from other types of information. It includes major system development of satellite infrared early warning, including flight testing. Studies are included to determine the relative suitability of airborne and satellite platforms for various tasks. Work is programed in advanced IR devices and other passive equipment.

Major studies and research in several supporting areas of basic science are essential to a sound program of major advances in the arts of very early warning.

Because field observation of missiles in flight already indicates great promise, maximum emphasis is placed on the task of applying infrared observations from

elevated vehicles to the problem. Since this task area is one in which costs of vehicles and their operation predominate, unbiased studies of the relative suitability of various air and satellite craft as observing vehicles, especially during the development phase, constitute a very important task.

Advance of the art of very early warning will require development of a certain quota of special advanced components. This must be prefaced by studies directed toward defining requirements to be met by new components, such as the properties of new materials that are needed, and for which in turn new methods of synthesis must be developed.

5. Cloud-cover surveillance:

Fiscal year 1959	$10,000,000
Fiscal year 1960	0

Accurate weather forecasting is useful for such military operations as (*a*) air strikes, (*b*) amphibious landings, (*c*) troop and material movements, and (*d*) prediction of radioactive fallout patterns. Satellites hold one promise of rapidly collecting weather data on a global basis. The data collected by satellites should result in increased reliability and accuracy of weather forecasting, particularly in times when local ground observations are not available. This program will explore the application of satellites to this goal.

Because of the general scientific implications of this program, NASA will assume its direction in fiscal year 1960, and funds for its continuation are in the NASA budget.

6. Manned satellite (cooperative program with NASA):

Fiscal year 1959	$8,000,000
Fiscal year 1960	0

Progress in rocketry has reached the point that a capability is fast approaching to place a man in orbit around the earth. Because human participation in space flight will have immense scientific and military implications, NASA and ARPA have joined in a cooperative program.

In 1960, funds for this program are being requested by NASA.

7. Discoverer:

Fiscal year 1959	$100,000,000
Fiscal year 1960	60,000,000

This program as now planned is composed of the following:

(*a*) *Engineering prototype tests.*—Specific objectives of the flight tests are the performance evaluation of major components and subsystems as they become available. They progress from flight-dyanmics investigation through separation tests, vehicle propulsion, guidance and stabilization during coast and transition to orbit, tracking, telemeter, and data link development, and to the preliminary testing of payload components. The purpose of this program is to develop a prototype vehicle suitable for demonstrating early orbital capability. Initial phases of the program use Thor boosters.

Ground tests will be conducted with system components and subsystems, the vehicle structure, and vehicle separation methods. Dynamic testing will be performed at contractor facilities, in wind tunnel tests and on rocket sleds. Experimental and developmental tests will be made to achieve satisfactory subsystem environmental control, heat rejection, radiation shielding and reliability estimates by simulating atmospheric, temperature, and radiation environment expected on orbit. Contractor facilities will be used for functional and operational tests of these subsystems prior to flight test.

The orbital test program is designed to yield actual environmental information as well as system performance characteristics, and will further serve to check out tracking and acquisition capabilities.

(*b*) *Biomedical recovery capsule.*—The biomedical recovery capsule program has three primary objectives. These are:

(1) To recover living specimens from orbital flight;

(2) To study the psychophysiologic response of specimens to conditions of launch, orbit, and recovery;

(3) To build experience and confidence in recovery techniques. These objectives will be achieved by launching biomedical recovery capsules into orbit on Discoverer flights. The capsules will be separated from the parent vehicle on later orbital passes and recovery attempted.

8. High-energy upper stage:

Fiscal year 1959	$15,000,000
Fiscal year 1960	0

As a part of its program for the development of vehicles for military space missions, ARPA initiated work on a new high-energy upper stage to provide maximum payload capability when used as a second stage to an ICBM vehicle, such as the Atlas, or as a third stage when the high-thrust booster is also used. Because of the great importance of high performance in upper stages, the high-energy propellant combination of hydrogen-oxygen was chosen.

In fiscal year 1960, responsibility for this project passes to NASA and funds for its continuation are included in the NASA budget.

9. Clustered-engine booster:

Fiscal year 1959	$19,000,000
Fiscal year 1960	50,000,000

The development of a high-thrust booster is approached in the direction of utilizing by parallel clustering engines and tankage from the ballistic-missile program. The use of these proven high-production components insures minimum development costs and time, while maintaining a very high degree of reliability. Eight engines similar to those used on Jupiter, Thor, and Atlas will be assembled on one supporting frame. Each engine operates independently and the arrangement is such that a single engine failure will not necessarily result in mission failure.

The clustered engine is expected to be operational several years before the single-chambered engine. The clustered booster combined with an ICBM and a high-energy upper stage will be capable of placing 30,000 pounds in a 300-mile orbit, impacting 7,000 pounds on the moon or placing 4,000 pounds in a 24-hour orbit. The clustered engine, utilizing the NASA-developed 1.5-million-pound engine as a central element of the cluster would have a combined thrust of 2.3 million pounds.

10. Tracking and data acquisition:

Fiscal year 1959	$17,000,000
Fiscal year 1960	17,000,000

Space exploration cannot be undertaken successfully without an adequate ground-tracking and data-acquisition network. It is realized that such a system could become very expensive and therefore careful coordination of the requirements of all potential users of such a network has been required. During the past year, ARPA, with the assistance of the Jet Propulsion Laboratory, studied needs for worldwide space-surveillance systems. This study took into consideration the needs of users other than the Department of Defense, with a view to providing mutual service and minimizing duplication. A similar study has been underway within NASA for the past several months. Recently, the two agencies and JPL have joined together as a joint committee. The results of this committee's work has culminated in an agreement between NASA and the DOD.

In essence, the agreement provides for the provision of four additional tracking and data-acquisition stations for deep-space probe and broadband data readout to be located at separate overseas locations. Two of these stations will be operated by NASA at the outset and two by Defense. Exchange of common data is provided in the agreement. The agreement also provides facilities for man-in-space and minitrack stations which NASA will operate but which will furnish data to Defense.

The need is recognized for two closely cooperating data reception and analysis centers; one operated by NASA as a continuation and expansion of the Vanguard center and one operated by the Department of Defense under Spacetrack management at the Cambridge Research Center. These two centers will exchange data freely and provide mutual support for the national program.

In addition, the so-called satellite-detection "fence," authorized in May 1958, is being continued by DOD/ARPA. Construction is essentially complete on this system. Experience to date indicates that additional work must be accomplished on this system in order to obtain maximum benefit from the stations now available.

11. Feasibility investigations and exploratory research:

Fiscal year 1959	$13,441,337
Fiscal year 1960	10,000,000

To fulfill its mission of conducting advanced research necessary to military space technology, ARPA must examine and test the feasibility of concepts, equipment, and proposals. ARPA must generate new ideas and novel techniques which hold promise of significantly improving military space applications. Essentially, these investigations in research projects will be looking for major breakthroughs rather than simply refining existing techniques and equipment. Specific areas of investigation include auxiliary power supplies, components, and materials development, and advanced control methods.

12. Scientific space investigations:

Fiscal year 1959	$22,784,663
Fiscal year 1960	0

During fiscal year 1958, ARPA initiated several scientific space projects such as the lunar-probe program. These projects were transferred to NASA effective October 1, 1958. These obligations are in addition to the $59,200,000 transferred to the NASA appropriation.

Programwide management and support

Executive and technical direction:

Fiscal year 1959	$1,900,000
Fiscal year 1960	1,900,000

The Advanced Research Projects Agency is responsible to the Secretary of Defense for the planning, development, administrative, and management of the various programs assigned. In the execution of its programs, extensive use is made of existing facilities and services of the military departments, other Government agencies, universities, and industry. Under this concept of operations, ARPA does not duplicate or add to that which already has been established and available in the way of facilities and personnel to carry out its program. Accordingly, APRA can execute its overall technical and administrative program planning and management responsibilities with a relatively small staff. Through a contract with the Institute for Defense Analyses, ARPA is provided highly specialized scientific and technical program proposals aand evaluations which are vital to the successful development, appraisal, and technical management of specific areas of advanced research, as assigned.

The funds requested provide for the salaries and other necessary expenses such as travel, communications, equipment, supplies, and professional services required in the planning, direction, and management of the program of advanced research.

[S. 1582, 86th Cong., 1st sess.]

A BILL To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) there is hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1960 the sum of $485,300,000, as follows:

(1) For "Salaries and expenses", $94,430,000.

(2) For "Research and development", $333,070,000.

(3) For acquisition or condemnation of real property, for plant and facility acquisition, construction, or expansion, and for other items of a capital nature, $57,800,000, as follows:

(A) Langley Research Center, Hampton, Virginia: Alterations to thermal structures tunnel; analytical computing equipment; conversion of gust tunnel to noise research laboratory; conversion of test cells to noise test facility; and heater and vacuum system for gas dynamics laboratory, $4,580,000.

(B) Ames Research Center, Moffett Field, California: Data reduction center and mass transfer cooling and aerodynamics facility, $6,555,000.

(C) Lewis Research Center, Cleveland, Ohio: Ion and plasma jet facility; zero-power reactor; in-pile loop; and approximately twenty-five acres of land, $6,860,000.

(D) High-speed flight station, Edwards, California: Building additions; analog computing equipment; and terminal guidance facility, $2,805,000.

(E) Beltsville Space Center, Beltsville, Maryland: Central flight control and range operations building; space sciences laboratory; instrument construction and installation laboratory; and utility installations, $14,000,000.

(F) Pacific Missile Range, Point Arguello, California: Launching facilities, including flight vehicle assembly and check-out facility with equipment for special experiments, $3,000,000.

(G) Various locations: Global range tracking and communication facilities and equipment; facilities for Rover program; and propulsion development facilities, $20,000,000.

(b) Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (A), (B), (C), (D), (E), (F), or (G) of subsection (a)(3) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $57,800,000.

SEC. 2. Any amount, not to exceed $500,000, of the funds appropriated pursuant to authorization of subsection (a)(3) of the first section for the construction of facilities described under such subsection may, with the approval of the Bureau of the Budget, be used for the construction of new research facilities or for the modification of existing research facilities not specifically authorized in this Act, if such construction or modification is deemed by the Administrator of the National Aeronautics and Space Administration to be of greater urgency than the construction of any facility authorized by this Act: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction of new research facilities or the modification of existing research facilities: *Provided further*, That no such funds shall be used for the construction or modification of any facility if funds for such construction or modification have been previously denied by the Congress.

Senator STENNIS. Our witness this morning will be Dr. T. Keith Glennan, Administrator of the National Aeronautics and Space Administration. Dr. Glennan, I would like you to examine the fiscal year 1960 budget justification for the Advanced Research Projects Agency carefully and advise this Committee whether these programs or estimates involve any duplication with those for which the National Aeronautics and Space Administration is requesting funds in its 1960 budget. Your reply will be inserted in the record at this point.

(The NASA reply is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., May 25, 1959.

Hon. JOHN STENNIS,
Chairman, Subcommittee on NASA Authorization, Committee on Aeronautical and Space Sciences, Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: At your request, the National Aeronautics and Space Administration has reviewed the fiscal year 1960 budget estimates of the Advanced Research Projects Agency submitted to us by your subcommittee.

The estimates submitted do not reveal any duplication in effort or funding of the programs for which the National Aeronautics and Space Administration is requesting moneys for its 1960 operation.

Sincerely yours,

T. KEITH GLENNAN, *Administrator.*

Dr. Glennan, it is always a pleasure for us to have you appear before the subcommittee and give us the benefit of your views. If you and the members of your staff who may testify would please stand, I will administer the oath.

Do each and every one of you solemnly swear that your testimony in this hearing will be the truth, the whole truth, and nothing but the truth, so help you God?

Dr. GLENNAN. I do.
Dr. DRYDEN. I do.
Mr. SIEPERT. I do.
Mr. ABBOTT. I do.
Mr. WYATT. I do.
Mr. BUCKLEY. I do.
Mr. ULMER. I do.
Mr. NUNN. I do.

(The biographical sketches of the witnesses follow:)

T. KEITH GLENNAN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

T. (Thomas) Keith Glennan is the first Administrator of the National Aeronautics and Space Administration, established October 1, 1958, under the National Aeronautics and Space Act of 1958.

As Administrator, Dr. Glennan heads a staff of scientists, engineers, technicians, and other employees engaged in research and development in aeronautics and space matters. In this position he is a member of the President's National Aeronautics and Space Council.

Glennan is president-on-leave of the Case Institute of Technology, Cleveland, Ohio, which he has headed since 1947.

Born in Enderlin, N. Dak., in 1905, Dr. Glennan earned a degree in electrical engineering from the Sheffield Scientific School of Yale University in 1927.

Following graduation, Glennan became associated with the newly developed sound-motion-picture industry, and later became assistant general service superintendent for Electrical Research Products Co., a subsidiary of Western Electric Co. During his career he was studio manager of Paramount Pictures, Inc., and Samuel Goldwyn Studios, and was briefly on the staff of Vega Airplane Corp.

Glennan joined the Columbia University Division of War Research in 1942, serving through the war, first as administrator and then as Director of the U.S. Navy's Underwater Sound Laboratories at New London, Conn. For his work he was awarded the Medal of Merit.

At the end of World War II, Dr. Glennan became an executive of Ansco, Binghamton, N.Y. From this position he was called to the presidency of Case. During his 11-year administration, Case rose from a primarily local institution to rank with the top engineering schools in the Nation. From October 1950 to November 1952 concurrent with his Case presidency, he served as a member of the Atomic Energy Commission.

Dr. Glennan has been very active in national and civic affairs. He was chairman of the board of the Institute for Defense Analyses, on the board of the National Science Foundation, and the Council on Financial Aid to Education. In Cleveland he took an important part in many civic activities.

Glennan is a fellow of the American Academy of Arts and Sciences, and a member of Sigma Xi, Tau Beta Phi, and Chi Phi. He has been awarded several honorary degrees of doctor of science.

Dr. and Mrs. Glennan (the former Ruth Haslup Adams) have four children. They live at 4740 Connecticut Avenue, NW., Washington, D.C., with their youngest daughter.

HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Hugh Latimer Dryden is the first Deputy Administrator of the National Aeronautics and Space Administration created by the Congress in the National Aeronautics and Space Act of 1958. At the time of his appointment, Dr. Dryden was Director of the National Advisory Committee for Aeronautics, the research agency which became the nucleus of the NASA. He headed the NACA staff from 1947 to 1958.

Dr. Dryden's duties in large part are concerned with the direction of the NASA staff of scientists, engineers, and technicians engaged in aeronautical and space

research and development. He serves as the Administrator's alternate on the National Aeronautics and Space Council.

Born in Pocomoke City, Md., in 1898, Dr. Dryden earned a bachelor of arts degree in 1916 and a Ph. D. in 1919, both from Johns Hopkins University.

Dr. Dryden joined the staff of the National Bureau of Standards in 1918 and 2 years later was promoted to head the Bureau's aerodynamics section. In 1934 he was appointed Chief of the Mechanics and Sound Division. He was named Assistant Director of the Bureau in January 1946, and Associate Director 6 months later.

Although Dr. Dryden performed important research at the Bureau on building materials and structures, his main field of interest was in aerodynamics, particularly turbulence and control of the boundary layer. He made some of the earliest studies in this country of airfoil characteristics near the speed of sound.

He resigned from the Bureau of Standards after 29 years of service, to head the NACA on September 1, 1947.

Dr. Dryden's many honors include the Presidential Certificate of Merit for his leadership in the development of the World War II Bat, the first American guided missile successfully used in combat. He was given the Medal of Freedom for his work in 1945 as Deputy Scientific Director of a group appointed to advise the Army Air Force on future research and development. His more recent awards include the 1950 Guggenheim Medal, the 1955 Wright Brothers Memorial Trophy, the Baltimore City College Hall of Fame (1958), and the 1958 Career Service Award of the National Civil Service League.

The recipient of several honorary degrees, Dr. Dryden has many professional affiliations including the National Academy of Sciences, the Institute of the Aeronautical Sciences, the American Physical Society, the American Rocket Society, and the American Association for the Advancement of Science. He is currently a member of several scientific committees advising Government agencies.

Dr. Dryden is married and has three children. The family home is at 5606 Overlea Road, Washington, D.C.

ALBERT F. SIEPERT, DIRECTOR OF BUSINESS ADMINISTRATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Albert F. Siepert has been Director of Business Administration since the National Aeronautics and Space Administration was established in October 1958. During the previous 10 years he was Executive Officer of the National Institutes of Health.

Born in Peoria, Ill., in 1915, Siepert received a bachelor of arts degree from Bradley University in 1936.

After graduation, Siepert became one of the first Government "interns" (trainees) under the auspices of the National Institute of Public Affairs. He served his internship with the Farm Credit Administration, and has since held administrative posts with the Home Owners' Loan Corporation, the Alien Property Custodian, and the Bureau of State Services of the U.S. Public Health Service.

Named Executive Officer of the National Institutes of Health in 1948, Siepert had a key role in a thoroughgoing reorganization and expansion of the Institutes during the initial years of his NIH appointment. He received the Arthur Flemming Award in 1950 for his contribution. In 1955 he received the Department of Health, Education, and Welfare's Distinguished Service Award for his administrative leadership.

Mr. and Mrs. Siepert and their two children live at 7209 Honeywell Lane, Bethesda, Md.

IRA H. ABBOTT, DEPUTY DIRECTOR OF AERONAUTICAL AND SPACE RESEARCH, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Ira H. Abbott has been appointed Deputy Director of Aeronautical and Space Research, National Aeronautics and Space Administration. He will continue to serve as Assistant Director of Research (Aerodynamics and Flight Mechanics), a position he has held since the NASA was established on October 1, 1958.

Abbott joined the National Advisory Committee for Aeronautics, the predecessor of the NASA, in 1929 as a junior aeronautical engineer at the Langley Aeronautical Laboratory, Va. During his 19 years at Langley he served as Assistant Chief of the Full-Scale Research Division and later Assistant Chief of the Research Department.

Transferred to NACA headquarters in Washington, D.C., in 1947 as aeronautical consultant, Abbott was named Assistant Director of Research (Aerodynamics) in 1949. Since the NASA was established, he has supervised basic research programs in fluid mechanics; aircraft, missile, and spacecraft aerodynamics; and control guidance and navigation.

Born July 18, 1906, at Wolfboro, N.H., Abbott was graduated from Newburyport (Mass.) High School. He received a bachelor of science degree from Massachusetts Institute of Technology in 1929.

Abbott is a member of the Civilian-Military Liaison Committee (authorized by the National Aeronautics and Space Act of 1958), and a fellow of the Institute of the Aeronautical Sciences. From 1957 to 1958 he was Chairman of the Wind Tunnel Panel of NATO's Advisory Group on Aeronautical Research and Development.

Mr. and Mrs. Abbott (the former Martha Leola Streeter) and their three children live at 3704 Bradley Lane, Chevy Chase, Md.

DeMarquis D. Wyatt, Technical Assistant to the Director of Space Flight Development, National Aeronautics and Space Administration

D. (DeMarquis) D. (Dale) Wyatt was appointed technical assistant to the Director of Space Flight Development when the National Aeronautics and Space Administration was established on October 1, 1958. Previously he was a member of the headquarters staff of the National Advisory Committee for Aeronautics, the predecessor of the NASA.

Wyatt is a native of St. Joseph, Mo., where he attended local grammar and high schools. He earned a bachelor of science in mechanical engineering degree from Missouri School of Mines and Metallurgy in 1941.

From 1941 to 1942 he was a test engineer with General Electric Co., and from 1942 to 1944 he was an instructor in mechanical engineering at Missouri School of Mines and Metallurgy.

Wyatt joined the NACA as a research engineer at the Lewis Flight Propulsion Laboratory, Cleveland, Ohio, in 1944. At Lewis he specialized in supersonic propulsion research, and ultimately was made Associate Chief of the Propulsion Aerodynamics Division. He was transferred to the NACA headquarters, Washington, D.C., in September 1958.

A member of the Institute of the Aeronautical Sciences, Wyatt is the author of numerous technical reports and scientific articles.

He is married to the former Louise Dunlap. Mr. and Mrs. Wyatt and their two children, Katherine, 11, and Keith, 8, live at 8407 Westmont Terrace, Bethesda, Md.

Edmond C. Buckley, Assistant Director for Space Flight Operations, National Aeronautics and Space Administration

Edmond C. (Collins) Buckley, former Chief of the Instrument Research Division of the Langley Research Center, has been appointed Assistant Director for Space Flight Operations at headquarters, National Aeronautics and Space Administration, Washington, D.C. Buckley joined the National Advisory Committee for Aeronautics, predecessor of the NASA, in 1930.

Reporting to the Director of Space Flight Development, Buckley is responsible for planning and directing the use of support systems for space research activities, including global tracking stations, data acquisition systems and networks, ground communications networks, and launch site facilities.

Born in Fitchburg, Mass., in 1904, Buckley earned a bachelor of science degree in electrical engineering from Rensselaer Polytechnic Institute in 1927. He joined the NACA at the Langley Research Center, Langley Field, Va. In 1943 he was named Chief of the Instrument Research Division. In this post he was responsible for the development and construction of electrical, mechanical, optical, and electronic instruments used in wind tunnels, specialized laboratories, and in flight vehicles including high-speed research airplanes and rockets.

Buckley is a member of the Instrument Society of America and is on the steering committee of the interrange instrumentation group.

Buckley, his wife and their two children have been making their home in Hampton, Va. They plan to move to the Washington area in the near future.

RALPH E. ULMER, ACTING DIRECTOR, BUDGET AND FISCAL DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Ralph E. Ulmer has been budget officer of the National Aeronautics and Space Administration and the National Advisory Committee for Aeronautics, the predecessor of the NASA, since 1950.

Born in Toledo, Ohio, in 1917, he earned a bachelor of science degree in aeronautical engineering from the University of Michigan in 1938.

Ulmer joined the NACA as a junior aeronautical engineer at the Langley Aeronautical Laboratory, Hampton, Va., after graduation in 1938. He specialized in propeller research before becoming an assistant to the Administrative Officer.

In 1940 Ulmer was transferred to NACA's Washington headquarters where he became assistant to the Executive Officer. In 1950 he was appointed Budget Officer.

Mr. and Mrs. Ulmer and their two children live at 5140 Tilden Street NW., Washington, D.C.

ROBERT G. NUNN, JR., ASSISTANT GENERAL COUNSEL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Robert G. Nunn, Jr., joined the National Aeronautics and Space Administration as Assistant General Counsel in October 1958. Previously he was in the Office of General Counsel, Department of the Air Force.

Born in Cape Girardeau, Mo., in 1917, Nunn earned a bachelor of arts degree from DePauw University in 1939 and a doctor of law (J.D.) degree from the University of Chicago in 1942.

After 4 years as an officer in the U.S. Army, Nunn entered private law practice in Washington, D.C., where he remained until 1951.

In Terre Haute, Ind., from 1951 to 1954, Nunn was a partner in the law firm Dix, Dix, Patrick, Ratcliffe & Nunn. He joined the staff of the General Counsel, Department of the Air Force, in 1954.

Nunn has been a member of the Indiana bar since 1942 and the District of Columbia bar since 1947. He is a member of the American, Indiana, and Federal Bar Associations.

Mr. and Mrs. Nunn and their three children live at 4613 North 26th Street, Arlington, Va.

Senator STENNIS. Senator Martin, is there anything you want to say before we start?

Senator MARTIN. No, Mr. Chairman.

Senator STENNIS. All right, Dr. Glennan, we will be glad to hear from you.

TESTIMONY OF DR. T. KEITH GLENNAN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NASA; ALBERT F. SIEPERT, DIRECTOR OF BUSINESS ADMINISTRATION, NASA; IRA H. ABBOTT, DEPUTY DIRECTOR OF AERONAUTICAL AND SPACE RESEARCH, NASA; D'MARQUIS D. WYATT, TECHNICAL ASSISTANT TO THE DIRECTOR OF SPACE FLIGHT DEVELOPMENT, NASA; EDMOND C. BUCKLEY, ASSISTANT DIRECTOR FOR SPACE FLIGHT OPERATIONS, NASA; RALPH E. ULMER, ACTING DIRECTOR, BUDGET AND FISCAL DIVISION, NASA, AND ROBERT G. NUNN, JR., ASSISTANT GENERAL COUNSEL, NASA

Dr. GLENNAN. Mr. Chairman, and members of the subcommittee, we are pleased to be back for the second phase of our presentation of NASA's $485,300,000 budget authorization request for fiscal year 1960.

During the week of April 7, we presented to the subcommittee the technical and scientific aspects of most of the principal projects in the current NASA space program.

I might say, Mr. Chairman, that to my mind the transcript of those hearings is the most comprehensive, understandable and educational document on the Federal Government's aeronautical and space activities that exists today. I hope that this record will be given wide public dissemination.

In this regard, as I have said before, I believe the members of the subcommittee deserve the appreciation of all of us for the time they have devoted to seeking the details of our program, details that are vital to sound judgment.

Today, we are happy to meet with you for a more detailed examination of the specific elements included in our fiscal 1960 budget authorization request.

I will make my opening remarks very brief because I do not want to go over the ground that was well-plowed on April 7. I should reiterate that this 1960 budget requests an increase of $101,226,468 over the amount available for fiscal year 1959, including, of course, supplemental appropriations now under consideration by the Congress. The 1960 budget, you will recall, falls into three categories: $94,430,000 for salaries and expenses, $333,070,000 for research and development, and $57,800,000 for construction and equipment.

This is, in our judgment, a sound and indeed a lean budget. I would like to cite, for example, what we plan to do with the $333,070,000 for research and development to enable us to get considerably more space mileage per dollar than originally seemed possible.

When we prepared our first 1960 budget estimates back in November of 1958, our program relied on the then current family of existing rockets, namely the Juno II's and Thor-Ables. Since that time, our continuing program review has demonstrated that further reliance upon these vehicles would be uneconomical because of their limited load-carrying capacity and lack of versatility. For example, neither of these rockets has upper stage guidance so we must spin-stabilize them, thus restricting both the mass distribution and the gross weight of the scientific payload.

Our studies led us to initiate development of more advanced and much more efficient vehicles. In conjunction with the Advanced Research Projects Agency of the Department of Defense, we prepared the national space vehicle program which includes the Centaur and Vega rockets.

As you know, the Centaur consists of a modified Atlas ICBM as the first stage, a high-energy second stage, and a 6,000-pound thrust third stage, now in development.

Vega is made up of a modified Atlas as first stage, a modified Vanguard first stage as second stage, and the same 6,000-pound thrust third stage as in the Centaur. Vega will be capable of placing more than 5,000 pounds in an earth orbit and it will be one of the first space vehicles capable of making extensive television surveys of the moon's surface. It will also permit significant communications relay satellite experiments and be able to launch two-man satellites.

Centaur, which will be able to place more than 8,000 pounds in a 300-mile orbit, should be capable of soft-landing a 730-pound scientific payload on the moon.

Out of our program review came the realization that we would still need some vehicles of the Juno II and Thor-Able type for general

space missions. We therefore centered on the Thor-Delta, which is the Thor-Able rocket with the addition of a coasting guidance system for general satellite and space probe work.

In order to get the Thor-Delta, Vega and Centaurs under way as soon as possible, we cut back our Juno II and Thor-Able launching schedule. We reduced our orders of Juno II's from 8 to 5; we placed orders for 12 Thor-Deltas, and we set in motion plans for the development and procurement of 8 Vegas. On July 1, 1959 we will assume procurement funding of Centaur vehicles from the Air Force.

We have decided not to order more Thor-Ables. After reexamining our flight schedule, we stretched out our firing period in terms of the availability of these new vehicles. This means the majority of these vehicles funded in the 1960 budget will be fired during calendar years 1960 and 1961. We are tentatively planning to start firing Deltas late in 1959, this year; Vegas near the middle of 1960, and Centaurs early in 1961.

You have already heard our officials and technical experts describe these vehicles and their capabilities in detail, but I would like to give you just a few highlights.

The Juno II can place about 80 pounds in a 300-mile earth orbit. The Delta can place 250 pounds in the same orbit, and the Vega 6,000 pounds. The Juno II payload in a 300-mile orbit costs us about $15,000 per pound for vehicle alone, compared with $5,000 per pound for Delta and $600 per pound for Vega. In a deep space probe, Juno II's vehicle costs $100,000 per pound; Delta's costs $50,000, and Vega's will cost $3,200 per pound.

In short, when these vehicles are fired we will get more weight into orbit and space more cheaply and more efficiently than heretofore.

Needless to say, we have no intention of shooting off these expensive fireworks for Fourth of July effects. We will fire our scientific payloads only when we are convinced that we have done everything humanly possible to give them a good chance of success, and when we have assured ourselves that the benefits promised justify the costs involved.

In this way, we hope we will continue to deserve the respect and support of the Congress and the people of the United States.

In my judgment and in the judgment of the administrative and technical officials who are with me here today, this is a constructive and soundly based budget.

I would now like to discuss with you our requests for funds in each of the following major areas: Research and development, construction and equipment, and salaries and expenses.

With your permission, I shall give the remainder of this testimony extemporaneously.

Senator STENNIS. Yes, sir.

Dr. GLENNAN. In the course of this, Mr. Chairman, I will call upon members of the staff to support individual parts of the budget.

Senator STENNIS. All right. You present the matters now in your own way and we will not interrupt unless we feel that it is a major item; otherwise, we will make memos and wait until the proper time.

Dr. GLENNAN. Now, if I may refer you to page 201 of the detailed budget justification book before you——

Senator STENNIS. All right, Doctor, page 201.

RESEARCH AND DEVELOPMENT—AIRCRAFT, MISSILE, AND SPACECRAFT RESEARCH PROJECTS

Dr. GLENNAN. On page 201 you have the research and development programs where you have both the amounts provided in fiscal 1959, allotments and supplementals and requested fiscal 1960 estimates.

Under the first category which is "Aircraft, missile and spacecraft research," we have three items—"Support of NASA plant"; "Support of the Jet Propulsion Laboratory plant"; and "Research contracts."

You will note a substantial increase in the support of the NASA plant item. This results, really, from a transfer of certain items which were considered last year under the "Salaries and expenses" category and which this year have been place under this "Research and development" category.

The $16,670,000 which is provided for the support of NASA plant, is for the sort of administrative maintenance and repair for small items of equipment and the propellants, the supplies which are necessary in the support of research programs in the NASA plant.

Essentially, the same is true of the JPL plant and you will note that these are identical in 1959 and 1960.

We are asking the Jet Propulsion Laboratory to continue their program of research, which is essentially unchanged as they go into the next year. During the course of this year, we will validate the program or change it as may seem desirable.

In the "Research contracts" category, we have research contracts with educational institutions, with nonprofit research laboratories, to a limited extent, and with industrial laboratories in support of our basc research activities.

Now, if you have detailed questions on these, I will be glad to answer them.

Senator STENNIS. Members of the committee, I see that if we follow these items right down the line in the justification books, there might be a brief question we would want to ask and I think that would be the best way to cover it.

Dr. GLENNAN. I think so.

Senator STENNIS. For instance, this item of "Research contracts"; I want to cover this point. Do you expect any great increase in those items over the years?

Dr. GLENNAN. From year to year?

Senator STENNIS. Yes.

Dr. GLENNAN. I would say, Mr. Chairman, not under any terms of a great increase. I would suspect that our support of basic research in the areas of interest to this agency, in the educational institutions of the country particularly, might perhaps double or even triple this over a period of years.

In other words, we might move from the $5.2 million to as much as $10 million or $15 million.

Senator STENNIS. Your idea there, of course, is to utilize talent and facilities that already exist?

Dr. GLENNAN. Exactly, and to identify, in the course of that work, promising young men who are in graduate school and working on these research contracts who we ultimately hope will be part of our governmental establishment.

Senator STENNIS. The reason I ask this is because we have to have help in a field like space. We have the military in many phases of it and it is piling up. I think it is one of the best possible programs, but at the same tme we have to guard against overlapping programs.

I have heard reports from various institutions where they just jump in and run for these Government contracts. Some seek a very favorable deal out of it, as you know.

Dr. GLENNAN. Senator, I have been on both sides of this.

Senator STENNIS. Yes. What is your comment on what you see in that picture?

Dr. GLENNAN. I think the advent of the Federal Council on Science and Technology is going to have a very good effect on just this sort of thing. In that Council, and I am a member of it, there will be an attempt made to regularize our relationships, if you will, with institutions of higher education and to more closely monitor this business of possible overlapping and jockeying for position.

I recall very well Senator Young's questions to me on this, on this business of duplication. We can have it in an area like this, just as much as we can have it any place else. On the other hand, Mr. Chairman, basic research, and that is what we are talking about here, is an area which this country has not supported as it should.

Senator STENNIS. Yes.

Dr. GLENNAN. Over the years, if, indeed, to get on with the business of providing the kind of understanding that is going to be necessary for our developing technology, we do run into a small amount of this. I think we ought to be willing to pay that price. You can never know in this area whether this or that is going to come out of a program in which you may have what appear to be duplications. I recall again your concern about this thing, Senator Young.

Senator YOUNG. Yes.

Senator STENNIS. There are no definite lines, but you will have to have a coordination of your basic research grants with the Department of Defense. How do you propose to do that; through this Council?

Dr. GLENNAN. Dr. Dryden would like to speak to that.

Dr. DRYDEN. There is already in existence, inter-exchanges of projects admitted and projects approved, between our agency and the National Science Foundation, the Office of Naval Research, the Office of Scientific Research in the Air Force, and the Office of Ordnance Research in the Army. In other words, as a regular procedure, we send to them a list of proposals made to us and the ones which we have appproved, and then in a similar way, they interchange with us. Institutions frequently send the same proposal to all of the agencies, and it is necessary, as you say, not only to avoid duplication in subject matters, but even duplication in supporting the same group if you act in ignorance.

Now, the functions of these different groups are vitally different. The Science Foundation has the responsibility for general support of

basic reseach by Executive order, and the agencies have the authority to do basic research which supports their mission. There is a further discussion of this on page 230 in this justification book, pointing out the areas in which we make such contracts. They are in support of the work that we are doing. In the physical sciences, the structural and special purpose materials for use and application to the space vehicles and aeronautics, propulsion methods, instrumentation, theory of information handling, in the cosmological sciences, astrophysics and astronomy, and which are concerned with material particles and bodies in space, there are variations in evolution.

Senator STENNIS. Pardon me, Doctor. I don't believe anyone is worried about voting for the money you need.

Dr. DRYDEN. No, no.

Senator STENNIS. We trust you gentlemen as to what programs you will go into, but we do have responsibility to try to avoid duplication of effort and duplication of spending money in these programs. How are you going to coordinate your program with this massive program of the Department of Defense?

Dr. DRYDEN. We do it by exchange of information on the proposals which Defense is considering in its basic research agencies between our office, the Office of Naval Research, the Office of Scientific Research in the Air Force, the Office of Ordnance Research in the Army, and furthermore, in the Department of Defense, a Committee on Basic Sciences deal with this problem.

Senator STENNIS. Yes; but where is the authority, though, to firm up the program and avoid anything more than the minimum amount of duplication?

Dr. DRYDEN. There is ARPA who has administrative authority over all the units in Defense, ourselves, and the Science Foundation. We are not knowingly going into the same area. It doesn't make any sense whatever to do exactly the same things. I think the confusion sometimes arises because if you can make a broad enough category, you say, "Are all these agencies doing basic research?"—Yes. "Are they doing basic research in physics?"—Yes. But, when you get down to the specific areas of projects, you do not find duplication.

Senator STENNIS. My point is that it seems to me somewhere you gentlemen ought to have an overall authority to coordinate and say "Yes" or "No," if necessary. You don't seem to have that now.

Dr. DRYDEN. I don't see, as a practical matter, how you make a unit of 8 or 10 Government agencies come under an outside administrator.

Senator STENNIS. You exchange lists of universities and colleges, I suppose, with the Department of Defense?

Dr. DRYDEN. Actual projects, and the amounts of money.

Dr. GLENNAN. Within our own organization, Mr. Chairman, we have just what you are speaking of, an office of Contract Research which gets those from each of the laboratories, space development and aeronautical research.

Mr. ABBOTT. May I add something to that?

Senator STENNIS. Yes.

Mr. ABBOTT. A great deal of this coordination takes place in the area of research by coordination meetings in which there are exchanges of opinion on various subjects.

For instance, only last week there was such a meeting held in the Science Foundation Building and was attended by technical people, experts in various phases of the program that was to be considered. There were also present people responsible for the administration of these contracting and grant programs, not only in the Science Foundation but all the people mentioned in the Department of Defense by Dr. Dryden and also by the Atomic Energy Commission in this case. They looked into all the proposals that were in a certain field of research from all the universities and research organizations and also all items from which these various people had information which they thought might be proposed in the future, as well as meetings now.

At this conference, there was a meeting of minds as to what general type of things should be supported and in some cases right down to specific projects. I think this is the most useful way of doing this. They change this very rapidly and the wisdom really doesn't reside in any single person to make arbitrary decisions.

Senator STENNIS. I wasn't trying to put you in a straitjacket, or anything like that.

Senator Martin, did you have a question?

Senator MARTIN. I would like to ask whether all the agencies were represented at this conference that you just described?

Mr. ABBOTT. Yes, sir; all the Government agencies that had an interest in this particular area.

Senator STENNIS. From the Defense Department and your own Agency?

Mr. ABBOTT. And the various branches of the Department of Defense.

Dr. GLENNAN. One of my colleagues makes a very good point on this, Mr. Chairman, that the shortness of funds in this general area of basic research is really a good break on this because none of us want to duplicate if we possibly can avoid it. We want the funds to go as far as they can in providing that sort of basic research.

Dr. DRYDEN. And the results go to everybody.

Senator STENNIS. Well, that is what I asked you. I am going to ask you now if you are certain that that is true, that the results go to everyone?

Dr. DRYDEN. Very certain.

Senator STENNIS. I know that I see some of these rocket programs in the military, where they get one started and want to keep it going regardless of everything else. I mean keep it in that particular service, as part of their zeal and esprit de corps. I don't suppose you have anything like that in basic research.

Dr. DRYDEN. Not in basic research.

Senator STENNIS. All right; I think you are talking about this $5.2 million item on page 201 of the justification book. You have a complete justification on pages 230 and 231. Why not just put those in the record, Dr. Glennan, as you come to your items? We will also place in the record pages 205 through 207 covering the justification for "Operational support of NASA plant" and pages 226 through 229 covering the justification for "Support of JPL plant."

Dr. GLENNAN. All right, sir.

Senator STENNIS. In that way it comes at the proper place in the record. You may proceed, sir.

(Pp. 201, 205 through 207, 226 through 229, 230, and 231 "Justification for research contracts," are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Operational support of NASA plant:

Fiscal year 1959	$11,726,102
Fiscal year 1960	16,670,000

1. OBJECTIVES

To provide funds for contractual services, repairs, alterations, minor construction, supplies, materials, and equipment required in the operation of all NASA activities.

2. JUSTIFICATION

Prior to the establishment of the NASA, all funds appropriated to the NACA were provided under two appropriation titles: "Salaries and expenses," and "Construction and equipment." The "Salaries and expenses" appropriation provided funds for the operation of all NACA activities and was a single year appropriation. The funds appropriated under "Construction and equipment" were no-year funds and provided for the construction, modernization, and equipment of the NACA physical plant.

A review of the legislative history of the National Aeronautics and Space Act of 1958, Public Law 85-568, approved July 29, 1958, indicates the intention of the Congress to retain within the "Salaries and expenses" appropriation title only those items normally required to be appropriated on an annual basis such as personal services, electric power, life insurance, retirement contributions, and similar items. The initial NASA fiscal year 1959 appropriation was approved on this basis. Flexibility in the programing of research activities was provided by including requirements for contractual services, supplies, materials, equipment, and similar items involved in plant maintenance and operation under the "Research and development" appropriation. Requirements for these purposes are grouped under the program heading entitled "Operational support of NASA plant."

The following table summarizes the chargeability of objects of expenditure by appropriation titles in accordance with the appropriation structure of the NASA as compared with appropriations previously made available to the NACA.

Object	NACA		NASA		
	Salaries and expenses (1-year)	Construction and equipment [1] (no-year)	Salaries and expenses (1-year)	Research and development (no-year)	Construction and equipment [2] (no-year)
01 Personal services	X		X		
02 Travel	X		X		
03 Transportation of things	X		X		
04 Communication services	X		X		
05 Rents and utilities	X		X		
06 Printing and reproduction	X		X		
07 Other contractual services:					
Educational institutions	X			X	
Government agencies	X			X	
Non-Government facilities	X			X	
Repairs and alterations	X			X	
Security investigations	X		X		
Federal life insurance	X		X		
08 Supplies and materials	X			X	
09 Equipment	X	X		X	X.
10 Land and structures		X			X.
11 Contributions (retirement)	X		X		
13 Awards and indemnities	X		X		
15 Taxes and assessments	X		X		

[1] Pursuant to agreement with Bureau of the Budget, all items of a capital nature in excess of $100,000 were included under this heading.

[2] Pursuant to sec. 307 of the National Aeronautics and Space Act of 1958, all items of a capital nature in excess of $250,000 are included under this heading.

The following tabulation summarizes the requirements for operational support of the NASA plant for the fiscal years 1959 and 1960:

Breakdown by objects	Fiscal year 1959			Fiscal year 1960 research and development
	Salaries and expenses	Research and development	Total	
07 Other contractual services:				
Research contracts	[1]($1,000,000)	[1]($3,000,000)	[1]($4,000,000)	[1]($5,200,000)
Government agencies	135,330		135,330	114,000
Non-Government facilities	596,900	153,000	749,900	935,000
Repairs and alterations	1,055,270	120,000	1,175,270	1,728,000
08 Supplies and materials	6,099,652	145,300	6,244,952	8,283,000
09 Equipment	3,250,150	170,500	3,420,650	5,610,000
Total	11,137,302	588,800	11,726,102	16,670,000

[1] Research and development program entitled "Research Contracts".

National Aeronautics and Space Administration

Fiscal year 1960 estimates

Support of JPL plant:
Fiscal year 1959 ..... $8,156,500
Fiscal year 1960 8,156,500

1. OBJECTIVES

The Jet Propulsion Laboratory, operated by the California Institute of Technology at Pasadena, Calif., under control and funding by the Department of the Army, has been carrying on research in many areas associated with the development of missiles and space vehicles. Some of this work had specific military application; a large portion of the work was more general in nature. The technical knowledge resulting from the work is applied to the design, propulsion, operation, and guidance of improved missiles and space vehicles.

2. HISTORY OF TRANSFER TO NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Act of 1959 (Public Law 85–568) gave the President authority to transfer to the newly established National Aeronautics and Space Administration "any functions—of any other department or agency of the United States—which relate primarily to the functions, powers, and duties of the Administration as prescribed by section 203 of this act." Pursuant to this authority, the President issued executive order 10793, dated December 3, 1958, which transferred "those functions (including powers, duties, activities, and parts of functions) of the Department of the Army or of any officer or organizational entity thereof which are now being performed at the Jet Propulsion Laboratory of the California Institute of Technology, near Pasadena, Calif. (hereinafter referred to as the laboratory), except so much thereof as relates primarily to military operations and weapon system development programs" to the National Aeronautics and Space Administration. The executive order also provided for the transfer of $4,078,250 from the Department of Defense to the National Aeronautics and Space Administration. This amount represents the estimated cost of operating the transferred functions for the period January 1, 1959 to June 30, 1959.

On December 3, 1958, an agreement entitled "Cooperative Agreement on the Jet Propulsion Laboratory Between the National Aeronautics and Space Administration and the Department of the Army" was signed by the Administrator, NASA, and the Secretary of the Army. This agreement defined the policies and procedures to be followed in carrying out the details of the transfer. Implementation of the agreement is now in progress.

On December 18, 1958, NASA order No. HS–41 was issued to the Jet Propulsion Laboratory providing authority and funds for the continuation of this work.

3. PROGRAM PHASING

The NASA plans to carry on the transferred functions of the Jet Propulsion Laboratory in accordance with the current research programs. Due to the calendar year funding method for the Jet Propulsion Laboratory now in use, funds for the period Jenuary 1, 1959, to December 31, 1959, will be supplied from the NASA's fiscal year 1959 appropriation for research and development ($8,156,500) and funds for the period of January 1, 1960, to December 31, 1960, will be supplied from the fiscal year 1960 appropriation ($8,156,500). During 1959 the research program of the Jet Propulsion Laboratory will be examined and reviewed to determine the areas where changes in emphasis may be required.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Guidance and control	$900,000	$900,000
Extreme range communications	300,000	300,000
Physical and electrochemical research in electronics	210,000	210,000
Guidance component research	220,000	220,000
Telemetering investigations	170,000	170,000
Missile engineering	590,000	590,000
Vehicle design studies	388,000	388,000
Structures	28,000	28,000
Application of superconductors	111,000	111,000
General studies	63,000	63,000
Solid propellant research and development	1,230,000	1,230,000
Propellant development	458,000	458,000
Propellant engineering	772,000	772,000
Liquid propellant research and development	1,450,000	1,450,000
Propulsion system development:		
45,000-lb. thrust N_2O_4/N_2H_4 system	615,000	615,000
20,000-lb. thrust engine	155,000	155,000
Propulsion system analysis	62,000	62,000
General supporting studies:		
Development of propellants and auxiliaries	315,000	315,000
Combustion and injection research	303,000	303,000
Advanced propulsion systems	314,000	314,000
Materials research	840,000	840,000
Solid state research	160,000	160,000
Metallurgy	245,000	245,000
Ceramics	108,000	108,000
Missile materials	172,000	172,000
Graphite	155,000	155,000
Basic studies in chemistry and physics	960,000	960,000
Applied chemistry	305,000	305,000
Propulsion physics	655,000	655,000
Instrument development	680,000	680,000
Instrumentation research	244,000	244,000
Computer research	436,000	436,000
Propellant and propulsion research	1,132,500	1,132,500
Heat transfer	355,000	355,000
Rocket motor injector research	200,000	200,000
High-performance storable liquids (chemical investigations)	24,000	24,000
High-energy solid propellant research	200,000	200,000
Atomization and injector hydraulics	53,500	53,500
Combustion research	300,000	300,000
Minor construction	60,000	60,000
Storage vault	18,000	18,000
Addition to cafeteria building	34,500	34,500
Miscellaneous	7,500	7,500
Total	8,156,500	8,156,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and development programs, fiscal years 1959 and 1960

Program	Fiscal year 1959		Fiscal year 1960 estimates
	Allotments	Supplemental	
Aircraft, missile, and spacecraft research:			
Support of NASA plant	[1] $588,800		$16,670,000
Support of JPL plant	8,156,500		8,156,500
Research contracts	[1] 3,000,000		5,200,000
Scientific investigations in space:			
Sounding rockets	5,000,000		10,000,000
Scientific satellites	23,252,000		22,800,000
Lunar probes	7,720,750		7,140,000
Deep-space probes	17,791,000		6,803,500
Vanguard program	25,541,282		
Satellite applications investigations:			
Meteorology	2,500,000		10,800,000
Communications	3,460,000		4,700,000
Space operations technology:			
Manned space flight	37,661,200	$20,750,000	70,000,000
Space rendezvous techniques			3,000,000
Space propulsion technology:			
Solid propellant rockets	700,000		3,000,000
High-energy propellant rockets	7,000,000		5,000,000
1,000,000-pound thrust single-chamber engine	10,000,000		30,200,000
Nuclear-rocket engines	4,500,000		8,000,000
Space engines	300,000		3,000,000
Auxiliary power units	500,000		3,000,000
Space systems technology:			
Advanced vehicle systems	500,000		1,500,000
Booster recovery systems	500,000		1,500,000
Orbiting space laboratories			2,000,000
Supporting activities: Tracking and data acquisition	3,300,000		11,500,000
Vehicle development:			
Scout	6,048,000		2,000,000
Delta	13,800,000		13,300,000
Vega	22,800,000		42,800,000
Centaur			41,000,000
Total, research and development	[1] 204,619,532	20,750,000	333,070,000

[1] Does not include $11,137,302 for support of NASA plant and $1,000,000 for research contracts provided in the "Salaries and expenses" appropriation. The revised estimate for support of NASA plant on a basis comparable to the 1960 estimate is $11,726,102, while that for research contracts is $4,000,000.

Fiscal year 1960 estimates

Research contracts:

Fiscal year 1959	$4,000,000
Fiscal year 1960	5,200,000

1. OBJECTIVES

To draw upon universities and other research establishments for fundamental and applied research necessary for advancing aeronautical and space technology.

2. JUSTIFICATION

In order to provide scientific knowledge for existing programs in aeronautical and space technology and to build a foundation for future programs, there is an urgent and continuing need for NASA to augment its present capabilities by utilizing the research potential of the universities and research institutes of the Nation. Not only must existing research groups be utilized but additional ones must be created to accelerate the advance of space sciences to the maximum extent. Important problem areas may be grouped as follows:

(1) The physical sciences encompass the fundamental research problems related to structural and special purpose materials, propulsion methods, instrumentation, theory of information handling and analysis, and others. To permit advances in applied science, increased understanding is needed in many areas of fundamental physical science.

(2) The cosmological sciences include planetary sciences, astrophysics and astronomy, which are concerned with characterizing material particles and bodies in space, radiation, their variations and evolutions, and the experimental tech-

niques of acquiring this knowledge. Practical questions such as tracking and guidance, environmental hazards of space flight, and the possible utilization of energy and matter in space all require substantially increased knowledge and techniques which must come from fundamental research.

(3) The life sciences include the fundamental study of physiology and biophysics to ascertain the limitations and hazards of manned space flight, owing to radiation, acceleration, weightlessness, and to other problems. Biochemistry related to sustenance of life, and behavioral adaptation in the space environment are also important basic research areas.

(4) The engineering sciences encompass important areas of fundamental engineering research, such as energy production and conversion processes, solid state or molecular transition electronic devices, guidance principles and techniques, trajectory problems, hypervelocity fluid dynamics, and plasma production, as examples. The calculation of optimum design and probabilities of mission performance, through system analysis techniques, requires research to increase the capability of this engineering science to permit treatment of the complex space systems.

(5) The NASA research associateship program, to be administered jointly by the National Academy of Sciences and the National Research Council, will provide to investigators of unusual ability and promise an opportunity for basic research in the various areas of science having to do with space exploration, including upper atmosphere physics, astrophysics, and plasma physics.

3. Program costs

	Fiscal year 1959	Fiscal year 1960
Physical sciences	$1,150,000	$1,100,000
Cosmological sciences	800,000	900,000
Life sciences	450,000	1,250,000
Engineering sciences	1,250,000	1,600,000
NASA research associateships	350,000	350,000
Total	[1] 4,000,000	5,200,000

[1] Includes $1,000,000 funded under the "Salaries and expenses" appropriation title.

SCIENTIFIC INVESTIGATIONS IN SPACE

Dr. GLENNAN. The next large item under the "Research and development programs" is "Scientific investigations in space." You will note there are five categories: Sounding rockets, $10 million; scientific satellites, some $22,800,000; lunar probes, $7,140,000; deep-space probes, $6,803,500, and the Vanguard program, which should be completed and will require no more money.

These programs are the basic, scientific investigations which we want to carry on in this new environment of space. Perhaps Mr. Wyatt can speak more definitely to any questions which you might have here. I would say what we are doing here basically is to study the phenomena that we may find out there of atmosphere, magnetic gravitational fields, radiation phenomena, and the sort of things that Dr. Homer Newell described so thoroughly to you back in April.

Dr. DRYDEN. His testimony on the scientific investigations in space can be found on pages 232 to 245 of the April hearings.

Senator STENNIS. All right, who is going to speak on those items?

Mr. WYATT. The first category of sounding rockets refers to essentially vertical traverse through the atmosphere to no more than 4,000 miles.

In our program for 1960 we contemplate the firing of something between 80 and 100 rockets to be procured with the funds from 1959

and 1960. These will be fired at a variety of locations around the country; Fort Churchill, Wallops Island, White Sands, the San Nicholas Islands and a few will be fired in Australia for observation in southern latitudes. These are all small rockets on the average. I think they aggregate a cost of perhaps $20,000 per rocket and they carry a payload up and down and give us a vertical traverse in a variety of fields. Some of these will study the atmospheric properties, ionispheric or electrically charged properties and these sort of things are incorporated into the payloads.

This is an extension in scope and in depth of the International Geophysical Year program and the general sounding rocket program that has been carried on in this country for about 12 years now. We are continuing it. The detailed justifications on this are on pages 232 to 234 of your books.

Dr. GLENNAN. We would like to place those in the record at this point.

Senator STENNIS. Pages 232 and 234 of the justification book will go into the record at this point.

(Pp. 232 through 234 of the sounding rockets justification are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Sounding rockets:	
Fiscal year 1959	$5,000,000
Fiscal year 1960	10,000,000

1. OBJECTIVES

To measure and understand the nature, extent, electrification, and dynamical behavior of the earth's atmosphere. To investigate the interactions of incident electromagnetic and particle radiations with the earth's atmosphere. To determine the relation between phenomena in the high atmosphere and surface meteorology. To conduct exploratory geophysical and astrophysical investigations leading to later satellite and deep space probe experiments.

2. JUSTIFICATION

A sounding rocket is defined as a rocket that can carry a usable scientific payload out to a distance up to one earth's radius from the surface of the earth. Such a vehicle affords a means of studying the earth's atmosphere in vertical cross section out to a distance at which it merges with the medium of interplanetary space. In support of the above objectives, many investigations of atmospheric structure, composition, ionization, motions, aurora, airglow, absorption of solar radiation, and interactions with cosmic rays and other particles can best be conducted by means of sounding rockets. The current NASA program continues the rocket sounding of the past 12 years, and is based on the experience obtained from the earlier work.

The current NASA sounding rocket program has three phases: (*a*) Investigations up to the E-region of the ionosphere at roughly 100 kilometers; (*b*) investigations in the region between 100 kilometers and the maximum of the F-region of the ionosphere at between 300 and 400 kilometers; and (*c*) investigations from 400 kilometers out to 6,000 kilometers. From the rocket sounding activity of the past 12 years a fairly complete picture of the atmosphere up to about 100 kilometers has begun to emerge. Phase (*a*) of the program is directed toward filling in the remaining gaps, and includes detailed measurements of geographic and temporal variations of atmospheric characteristics and high-altitude phenomena, using smaller sounding rockets like the Arcon. Between 100 and 400 kilometers a considerable amount of data have been accumulated, but only enough to delineate the bare outlines of the whole picture. Phase (*b*) of the NASA program is directed at investigations of this portion of the atmosphere, using moderate altitude rockets like the Aerobee-Hi, Iris, and Spaerobee. Above

the 400-kilometer level, rocket sounding is only in its beginning stages. Phase (c) will pick up this part of the work, using high-performance rockets and rocket combinations that will be adapted especially for the task.

3. PROGRAM PHASING

The 1959 funds will permit the procurement of approximately 50 sounding rocket boosters. Funds are also included for the development of improved sounding rockets, and for payload development, and fabrication. The payloads will be developed partly at the NASA Spaee Projects Center and partly under contract. The 1960 funds will provide some 100 rocket boosters and payloads.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Studies on measurement techniques	$200,000	$300,000
Sounding rocket systems studies	100,000	200,000
Prototypes and operational hardware:		
Rocket vehicles	1,000,000	2,000,000
Payloads	1,000,000	2,000,000
Developmental sounding rockets	1,000,000	2,000,000
Operations and technical services:		
Launching of rockets	400,000	900,000
Data acquisition, reduction and analysis	300,000	600,000
Supplies, equipment, repairs, and alterations: Test equipment, mobile launching units, recording materials, minor modifications to existing facilities	1,000,000	2,000,000
Total	5,000,000	10,000,000

Mr. WYATT. In the area of scientific satellites, the detailed justification is shown on pages 235 through 237 and we would like to place that in the record.

Senator STENNIS. All right; place them in the record.

(Pp. 235 through 237 of the justification for scientific satellites are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Scientific satellites:

Fiscal year 1959	$23,252,000
Fiscal year 1960	22,800,000

1. OBJECTIVES

To determine the nature, extent, and dynamical behavior of the earth's outer atmosphere, and its relation to the medium of interplanetary space. To determine and understand the nature, extent, dynamical behavior, and causes of the earth's ionsphere. To understand the nature, extent, and temporal variations in the gravitational, magnetic, and electric fields in the vicinity of the earth. To understand the origin, nature, motions, spatial distributions, and temporal variations of particles reaching the vicinity of the earth and having energies appreciably greater than thermal. To investigate the electromagnetic radiations reaching the vicinity of the earth, from gamma rays to radio waves, and to use such observations to extend knowledge of the sun, stars, and matter in space, and of the atmospheres of the earth and other planets. To determine and understand the interrelations among the above-listed phenomena. To determine and understand the environmental conditions encountered in the atmosphere, in space, and in vehicles traversing these regions, and their effects on materials and equipment. To determine the effects of conditions in the atmosphere and space and of flight through these regions on living organisms, and to understand the behavior of such organisms under these conditions.

2. JUSTIFICATION

The projects listed below support the above objectives by providing a series of exploratory measurements intended to give order-of-magnitude estimates of the quantities under observation, and to probe for new discoveries. The exploratory measurements will be followed by a series of more advanced experiments designed to make accurate measurements within the ranges indicated by the earlier exploratory investigations. Carrying out a number of the investigations in the NASA Space Projects Center will provide a stable nucleus for the program, while the participation of universities and other research agencies will greatly broaden the base and strength of the total program.

3. PROGRAM PHASING

The current satellite space-research program includes three phases: (*a*) Lightweight exploratory payloads for survey-type observations; (*b*) lightweight sophisticated experiments for quantitative measurements; and (*c*) heavier orbiting space laboratories of increased scope and complexity. Initial satellites to be launched in 1959 will carry exploratory IGY experiments that justify repetition. Lightweight sophisticated packages will follow in 1960, to study energetic particles, atmospheric properties, ionospheric characteristics, and geodesy. Heavier payloads, such as stabilized telescopes and atomic clocks will be developed and launched when ready. Exploratory biological experiments will be prepared. Meanwhile, with the help of previous results, additional sophisticated payloads in disciplines including atmospheric and ionospheric structure and composition, energetic particles and magnetic fields, solar radiations, and satellite environment, will be developed and prepared for launching.

The 1959 funds will allow the procurement of six satellite systems using three Jupiter, and two Thor-Able boosters. Funds are included for payload design, development, and tests; for reduction and analysis of resultant scientific data; and for collateral theoretical investigations. The 1960 funds provide for the purchase of two additional Juno boosters as well as the payload systems for the Thor-Deltas and the Jupiters.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies	$1,000,000	$3,000,000
Prototypes and operational hardware:		
Juno II satellite vehicles (5 units)	8,540,000	4,000,000
Thor-Able satellite vehicles and payloads (2)	7,120,000	
Satellite payloads	2,850,000	6,150,000
Operations and technical services: Assembly and launch of experimental vehicles and data acquisition, reduction, and analysis	2,742,000	6,650,000
Supplies, equipment, repairs, and alterations	1,000,000	3,000,000
Total	23,252,000	22,800,000

Mr. WYATT. These refer to the satellites which circle the earth in different paths depending upon the place and direction at which they are launched and these are scientific instrumented payloaded packages, again to study the wide variety of scientific fields of the sort that Dr. Glennan referred to. We have been conducting such a program of course, this year, and placed several satellites in orbit and we expect to extend that program through the fiscal year 1960 funding, which will carry through a flight program into calendar year 1961.

The funds we request here will give us the payloads and the backup moneys to carry this scientific satellite period through that time period. You might notice that in arriving at our 1960 costs, in 1959 we included the cost of what we call essentially off-the-shelf vehicles. These are the Juno II vehicles and the Thor-Able vehicles which are included in 1959.

Now, in 1960 we are including $4 million for additional Juno II vehicles, but the other vehicles that will actually be used in this program are not off-the-shelf items and they will be covered subsequently in the items under vehicle development, so that the 1960 budget is predominantly the cost of the payload, the special studies, the workup of the data and the support in the launching flight operations for this scientific satellite program.

Senator STENNIS. All right; that brings you down to this item now on the Vanguard, which goes out.

Mr. WYATT. No, sir, if I may, there are two items before that on "Scientific investigations in space." These are the lunar probes and deep-space probes.

Senator STENNIS. All right.

Mr. WYATT. At pages 238 through 244 of the justification book. They may be put in the record.

Senator STENNIS. They will go in at this point.

(Pp. 238 and 244 of the justification for lunar probes and deep-space probes are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal Year 1960 Estimates

Lunar probes:	
Fiscal year 1959	$7,720,750
Fiscal year 1960	7,140,000

1. OBJECTIVES

To develop vehicles and associated systems with advancing capabilities for the scientific investigation of space phenomena out to the distance of the moon and of the moon itself; and to utilize such vehicles for the acquisition of fundamental information on the radiation, field, and particle properties of cislunar space, and on the mass, configuration, surface details and composition, structural features and dynamics, atmospheric composition and density, magnetic and gravitational fields, radioactivity, biological systems, and other scientific characteristics of the moon.

2. JUSTIFICATION

Recent investigations in the space regions within an earth radius of the surface by means of vertical sounding rockets and earth satellites have already greatly extended man's knowledge of physical and chemical phenomena constituting the earth's environment and exposed important new processes that warrant more detailed investigation. Information of this type is a basic requirement for the understanding of problems concerning meteorology, communications, cosmology, and biophysics. Advancement of knowledge in these areas will require, in addition to an intensification of sounding-rocket and earth-satellite investigations, an extension of environmental measurements to much greater distances from the earth.

As part of this outer environment, and as our nearest major body in the solar system, the moon itself offers important potentialities for better understanding of historic and contemporary phenomena of the solar system and for clarification of some basic physical, chemical, and biological concepts that are fundamental to modern science.

Space flight systems can provide a revolutionary capability for investigation of such problems. A prominent phase of the NASA space-flight program will, accordingly, be directed to the development and utilization of space vehicles for the advancement of scientific knowledge concerning cislunar space and the moon itself.

3. PROGRAM PHASING

As approved by the President, the DOD Advanced Research Projects Agency undertook the development and construction of three Thor-Able and two Juno II lunar and cislunar space probes. On establishment of the NASA these projects

were assigned for final funding by the NASA during the fiscal year 1959. These probes are permitting evaluation of initial problems associated with the placing of space vehicles in circumlunar trajectories and in loose satellitelike orbits about the moon, and should provide some preliminary information on the environmental characteristics of cislunar space and, possibly, certain gross characteristics of the moon itself.

During the fiscal year 1959, work will be initiated on the development of advanced probes with improved capabilities for conducting cislunar space investigations and for evaluating the problems involved in establishing vehicles in more precise lunar orbits as the first step in acquiring more detailed information on lunar characteristics. Advancement of the technology of midcourse guidance and long-distance data transmission is basic to the success of this mission and emphasis will be placed on the resolution of these problems.

The project will be continued in the fiscal year 1960, and as system development is completed, launchings of precision lunar orbiters will be scheduled. In addition to the demonstration of vehicular capabilities, such probes should provide advanced information on cislunar and lunar magnetic fields, micrometeoritic distributions, and radiation and cosmic particle properties. It is hoped that improved information on lunar mass will be provided and high-resolution mapping of the moon's surface achieved.

Studies and preliminary development projects will be undertaken in the fiscal year 1959 and extended in the fiscal year 1960 to acquire technology for a more advanced lunar vehicle with a capability for executing a controlled lunar landing. Such a vehicle would provide important potentialities for detailed scientific exploration of local physical, chemical, and biological characteristics of the moon. Investigations of terminal guidance systems, orientation devices, landing controls and motors, robot erecting and experiment mechanisms, and special scientific sensors will be required. It is not expected that such vehicles will be available for launching before 1961.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Basic investigations to develop advanced midcourse guidance, orientation, scientific sensor, command control, and data handling and transmission components and systems	$575,000	$1,000,000
Basic investigations to develop terminal guidance systems, landing controls and motors, robot mechanisms, and special scientific sensors for lunar landing vehicles	300,000	800,000
Prototypes and operational hardware:		
Balance of funding for construction and flight tests of 3 Thor-Able and 2 Juno II lunar probes transferred from ARPA	4,810,000	----------
Research, development, and construction of advanced midcourse guidance and control, scientific sensors, and data handling and transmission systems for lunar-probe payloads	1,500,750	3,100,000
Operations and technical services: Assembly and launch of experimental vehicles and data acquisition, reduction, and analysis	285,000	1,240,000
Supplies, equipment, repairs, and alterations	250,000	1,000,000
Total	7,720,750	7,140,000

Deep-space probes:

Fiscal year 1959	$17,791,000
Fiscal year 1960	6,803,500

1. OBJECTIVES

To develop vehicles and associated systems with advancing capabilities for the scientific exploration and evaluation of deep-space phenomena; and to utilize such vehicles for the acquisition of fundamental information on the constituents, processes, and characteristics of the solar system, particularly as they influence the geophysical, astrophysical, and cosmological sciences.

2. JUSTIFICATION

Man's effort to identify, understand, predict, use, and possibly control elements of his natural environment must take into account the numerous factors and

influences associated with the cosmic domain. Until recently, progress along these lines has been subject to the limitations imposed by remote observations and indirect measurements. Space-flight vehicles now offer an important research capability for circumventing many of these limitations and thereby permitting verification, clarification, and vast extension of existing information on space phenomena.

In particular, instrumented vehicles of appropriate design may explore the variation of pertinent physical and chemical characteristics of space with distance from the sun and provide a wealth of fundamental information on the spatial distribution, nature, magnitude, dynamics, temporal variations, and interactions of micrometeorites, energetic particles, electromagnetic radiations, magnetic fields, electrons, ions, hydrogen, and the sun's atmosphere in the solar system, and on their relation to phenomena experienced on earth. Investigations of the major bodies of the solar system themselves should provide further insight into the relative characteristics of various components of the system, the influence of particular environments on planetary physics, chemistry, and biology, and on the historic and contemporary processes of the solar system.

3. PROGRAM PHASING

During the fiscal year 1959 a project is being undertaken to develop an initial vehicular system with potentialities for flight to the vicinity of the Venus orbit on essentially a minimum-energy trajectory. Two vehicles, one based on the Thor-Able and the other on the Atlas-Able propulsion systems will be constructed. It is anticipated that guidance, tracking and data transmission will be crucial to this operation. Accordingly, while it is planned that some scientific instrumentation will be carried to provide preliminary information on radiation, particle, and field characteristics along the flight path of the vehicle, considerable emphasis will be placed on the demonstration and evaluation of system requirements for future deep-space experiments. Concurrently, study and development projects will be undertaken to provide improved vehicular subsystems and operating techniques with refined and extended capabilities for more advanced experiments.

During the fiscal year 1960 the Vega vehicle system will be under development. Such a vehicle will make possible a wider range of scientific missions by offering a greater payload-carrying capacity, and/or sufficient energy to penetrate to greater distances toward or away from the sun. Development and construction of the advanced guidance, the instrumentation, and the data-handling and data-transmission systems which will be used in the payload for such missions will also be undertaken. It is not expected that the advanced probes will be available for launching before 1961.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Investigations of advanced midcourse guidance and control, tracking, and data handling and transmission systems	$840,000	$850,000
Investigations of scientific instrumentation for evaluating planetary and deep-space charecteristics	800,000	800,000
Prototypes and operational hardware:		
Development, construction, and launch of initial Thor-Able and Atlas-Able deep-space probes (2)	8,990,000	----------
Development of advanced midcourse guidance and control, data handling and transmission and instrumentation systems for deep-space payloads	6,401,000	3,653,500
Operations and technical services: Assembly and launch of experimental vehicles and data acquisition, reduction, and analysis	600,000	1,000,000
Supplies, equipment, repairs, and alterations	160,000	500,000
Total	17,791,000	6,803,500

Mr. WYATT. Now these are related in that they are probes away from the earth, and bodies that do not return to the earth but eventually go into orbit around the sun. They are differentiated by the objective of the shot.

The lunar probes refer to those shots directed to the vicinity of the moon itself.

The deep-space probes refer to shots that go beyond 4,000 miles since we have restricted our sounding-rocket definition to a 4,000-mile altitude, on out to the vicinity of the nearby planets, Mars and Venus.

Our provisions in both of these items in 1960 are for the procurement of payloads and associated expenses to the conduct of these sort of programs. Again I draw your attention to the fact that in our 1959 funding we include the cost of some of the conventional, off-the-shelf vehicles. In our 1960 costs, we will not be using any of the conventional vehicles and, hence, the vehicles again will be carried under a separate item of vehicle development.

The chart placed up here shows the number of firings that we expect to make in the calendar years 1959, 1960, and 1961. As I indicated, the funds that we are requesting for fiscal year 1960 will support the payloads and the associated expenses for the firings through calendar year 1961. This is because of the leadtime required to acquire the vehicles and the payloads themselves.

(The chart is as follows:)

Tentative vehicle schedule

	1959	1960	1961
Satellites	6	8	3
Lunar probes	1	2	2
Space probes	1	4	1
Meteorology	1	1	2
Communication	1	1	3
Test vehicles	1	4	5

Senator STENNIS. So your reduction on the deep-space probes from $17 million plus to $6 million plus is your difference there?

Mr. WYATT. It reflects a difference in bookkeeping in that in 1959 we include the cost of the vehicles. In 1960, the vehicles are special vehicles and not included in this item.

Senator STENNIS. Are there other questions on that group?

Dr. GLENNAN. Mr. Chairman, at the end of this session if we could go into executive session we would like to show you the more detailed situation.

Senator STENNIS. All right, Dr. Glennan.

SATELLITE APPLICATIONS INVESTIGATIONS

Dr. GLENNAN. Our next general category is "Satellite applications investigations." Meteorology is $10,800,000; communications, $4,700,000, and at this point if we could put into the record pages 250 through 255 of the justification book, Mr. Chairman, and cite from your earlier subcommittee report pages 228 to 244, and pages 251 to 265.

Senator STENNIS. All right, Mr. Reporter, put them in.

(Pp. 250 through 255, justifications for "Satellite applications investigations," are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal Year 1960 Estimates

Meteorology:

Fiscal year 1959	$2,500,000
Fiscal year 1960	10,800,000

1. OBJECTIVES

To establish a meteorological satellite capability which would make possible within the next decade a fully operational system having worldwide coverage. To develop for this system stabilized satellites for polar orbits of 500- to 1,000-mile altitude and "stationary" satellites for equatorial orbits of 22,000-mile altitude. To develop suitable radiation-detection equipment, including television, infrared detectors, and radar to measure such things as cloud cover, storm location, precipitation, temperature, wind direction, heat balance, and water vapor. To develop data-transmission techniques for continuously feeding information into a national weather center managed by the U.S. Weather Bureau. The large amounts of data will probably require satellite-to-satellite transmisison and special computing-machine techniques on the ground. A worldwide tracking and telemetering network will be required.

2. JUSTIFICATION

The earth satellite represents a new observational tool which promises to be of great value to the science and the practice of meteorology. Although it would be a mistake to imply that such a device will eliminate our meteorological limitations, there is no doubt that it will supply a tremendous amount of useful meteorological data not now obtainable. It will do this not only because of its ability to give worldwide coverage of some meteorological parameters, in contrast to the current 5 to 10 percent coverage, but also because of its unique vantage point above the atmosphere which will make new measurements possible. Improvements in basic scientific understanding, climatology, forecasting, and weather-control techniques should result.

The benefits to be derived from improved capacity in meteorology include convenience in planning personal activities; protection of life and property from weather disasters; safeguarding transportation; crop planning, control, and protection; industrial planning of weather-dependent products, outdoor enterprises, and heating and cooling loads; eventual limited weather control; and good will in return for providing these services to less fortunate people. In addition, the same meteorological data required for worldwide civilian needs can, by proper handling, be made to meet special military needs as well.

3. PROGRAM PHASING

Items to be purchased with the fiscal year 1959 funds which will initiate the program include (*a*) radiation detection equipment and associated ground equipment for a meteorological satellite (Tiros) to be launched before the end of 1959 and in the spring of 1960; (*b*) tracking, telemetering, data-processing and data-analysis equipment and services for these satellites; and (*c*) development of equipment for a series of stabilized follow-on meteorological satellites.

The fiscal year 1960 funds are designed to carry on this program at an accelerated rate. Some funds will be required for operational services related to the second Tiros launch. The majority of the funds will be required to complete item (*c*) preparatory to two launchings in 1961.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Research and development on advanced instrumentation	$1,100,000	$1,000,000
Systems studies	150,000	200,000
Prototypes and operational hardware: Meteorological satellite development and procurement	850,000	6,300,000
Operations and technical services: Data acquisition, reduction, and analysis	200,000	2,500,000
Supplies, equipment, repairs, and alterations	200,000	800,000
Total	2,500,000	10,800,000

Communications:

Fiscal year 1959	**$3,460,000**
Fiscal year 1960	**4,700,000**

1. OBJECTIVES

To develop communication satellites and operating techniques suitable for use in a worldwide communications system; such satellites would be intended as relay stations for ground-to-ground, ground-to-satellite, and satellite-to-ground transmissions of messages, data, voice, and television.

To conduct research and development in the following areas in support of this program: (*a*) Passive relays which reflect radio waves omnidirectionally, as with a sphere, or directionally, as with a corner reflector which must be aimed; (*b*) active relays which repeat messages immediately or at some delayed time; (*c*) high-power directional antennas for ground and satellite installation; (*d*) sensitive "low noise" receivers; (*e*) stabilizing and aiming devices; (*f*) lightweight power supplies; (*g*) "stationary" satellites in equatorial orbit; (*h*) propagation of electromagnetic radiation; and (*i*) world communication needs studies.

2. JUSTIFICATION

Long-range communications in the form of telephone, telegraph, and television networks are now accomplished by means of landlines, cables, longwave and shortwave radio, and microwave relay stations. The total bandwidth of landlines, cables, and low-frequency radio is limited. Shortwave-radio bands are crowded and are unreliable because of atmosphere interference and ionospheric irregularity. Ultra-short-wave and microwave radio is usually limited to line-of-sight range; long-distance communications at these frequencies is commonly achieved by means of repeater stations.

Satellites offer the possibility of worldwide communications by ultra-short-wave or microwave radio because the line-of-sight range at satellite altitudes is very large. The bandwidth or channel capabilities at these wavelengths is sufficient for television and most other foreseeable communications needs.

3. PROGRAM PHASING

In the fiscal year 1959, NASA efforts on communication satellites are being directed toward preliminary experiments with a spherical-reflector satellite. A 100-foot-diameter sphere will be placed in orbit in the winter of 1959 and various experiments on tracking and on propagation of radio waves will be conducted. In addition, studies of more sophisticated satellites, world communications needs, and the accompanying ground equipment are being initiated. In 1960 and 1961, three additional large spheres will be launched as well as one repeater-type communications satellite.

The major item of expense in the fiscal year 1959 is completion of the first 100-foot-sphere experiment. The program will be expanded during the fiscal year 1960 to include the additional sphere experiments as well as development of an active repeater payload suited to commercial television and data-relay needs. Support for development of stabilization systems and a 22,000-mile orbit capability is included.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Satellite stabilization		$200,000
Repeater satellite		700,000
Passive reflector	$160,000	200,000
System and long-range needs		200,000
Ground support		200,000
Prototypes and operational hardware: Payloads	3,150,000	1,100,000
Operation and technical services: Data acquisition, reduction, and analysis	100,000	1,500,000
Supplies, equipment, repairs, and alterations	50,000	600,000
Total	3,460,000	4,700,000

Dr. GLENNAN. You had, in the earlier discussions, a pretty thorough description of what we planned to do in these particular fields. These are the fields where we believe we can move toward operational systems within the next several years.

The communications program can be developed, which will probably interest commercial companies and where the meteorological satellite will provide, both to the military and to ourselves, substantial progress in better weather forecasting.

Senator STENNIS. May I interrupt you for a question?

Dr. GLENNAN. Yes, Mr. Chairman.

Senator STENNIS. Take weather forecasting. Do you think that will be practical—will it tie into, for instance, forecasting for crops, agricultural forecasting, and then on the other hand, to commercial aviation? I know we covered that some before, but I think you can touch on that lightly now, if you will.

Dr. GLENNAN. We certainly believe that it will be possible to improve the quality and accuracy of weather forecasting. The extent to which this can be done, that is the length of time, the time period over which this can be done, be it a week or month, is yet to be determined because we know so little, really, about the formation of weather in many, many parts of the world. I think that somewhere between 10 and 20 percent of the world's surface presently is covered by some kind of weather-formation-gathering equipment.

It seems clear to us that the ability to find out what is forming up will allow us to forecast weeks in advance and as our friends in the Weather Bureau said to us, that if this can be done and we can improve the accuracy by 10 percent, this will prove a very great benefit, not only to the United States, but to the world in general. This, I think, is a system which we just cannot afford to go after without real vigor, Mr. Chairman.

Senator STENNIS. The commercial companies are following the possible applications of communications satellites very closely, I imagine, aren't they?

Dr. GLENNAN. Yes, they are, sir.

Senator STENNIS. And have some of them their own experiments? Are they getting into that field themselves?

Dr. GLENNAN. Yes; we have under negotiation at the present time a contract for cooperation with at least one of the large commercial companies in the communications field, and they are spending their own money, sir.

Senator STENNIS. That's the American Telephone & Telegraph Co.?

Dr. GLENNAN. Yes, sir. Invitations, by the way, are being given to other companies in the field to join with us on this, as well.

SPACE OPERATIONS TECHNOLOGY

Dr. GLENNAN. The next major category is "Space operations technology," principally taken up, of course, with "Manned space flight" for a total of $70 million for 1960, with a small amount of $3 million for "Space rendezvous techniques." Here again, I would ask to be placed in the record pages 256 through 261 of the justification book and one can cite the pages in your committee document, 333 to 389.

(Pp. 256 through 261, justification for space operations technology, are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Manned space flight:	
Fiscal year 1959	$37,661,200
Fiscal year 1959 supplemental	20,750,000
Fiscal year 1960	70,000,000

1. OBJECTIVES

To provide a capability for accomplishing advanced space flight missions with vehicles where onboard human intelligence and operations are required. It will be a basic objective of the NASA to rationalize and refine the technology of manned space flight vehicles and associated systems, to achieve successful orbital flight and recovery of a manned satellite with an ICBM-booster and drag-reentry system, to evaluate the physiological and psychological effects of a space environment on man, to establish his capabilities and limitations for performing useful missions in space, and to devise and develop improved manned vehicles with increased capabilities for performing important advanced missions.

2. JUSTIFICATION

It is becoming increasingly evident that full exploitation of the potentialities of space flight for benefiting mankind will be dependent on the development of practical capabilities for operating manned space vehicles. While it may appear in principle that suitable instrumentation may be devised to perform increasingly complex space missions, in practice the availability in a vehicle of human intelligence and operational capabilities will prove to be the most effective method for successful accomplishment of many advanced space flight missions. In particular, he can contribute to the tasks of space exploration and utilization an observational, analytical, and decision making ability concerning both expected and unanticipated problems, and a vast flexibility of action for operation, correction, and maintenance of scientific and technological instrumentation and equipment that characterize his present usefulness in airplanes and the scientific laboratory.

In order to provide this capability a progressive program of research and development has been undertaken. A broad range of investigations directed to the solution of basic technological problems concerning vehicular configurations and construction, human factors, life support equipment and accommodations, launching systems, stabilization and control, reentry and recovery systems and techniques, operational and scientific instrumentation, and other vehicular subsystems has been initiated.

On the basis of extensive studies it has become evident that the first manned orbiting flight vehicle should be based on the use of an ICBM-booster launching system and the ballistic type of drag reentry into the atmosphere. The relative simplicity and reliability of this approach at the present state-of-the-art offers the best potentiality for early success and will yield a vehicle with a wide range of usefulness for investigating problems concerning both human and vehicular operation factors. This vehicle is also a logical steppingstone to larger systems of the same type with greater capacity for performing both scientific, civil and military services. In addition, it is adaptable to the investigation of both reaction-type space-path control and aerodynamic-lifting systems that will give later manned space vehicles a greatly increased scope of operations.

3. PROGRAM PHASING

During the fiscal year 1959, a wide range of studies and experimental investigations is being initiated to assess the problems that will be encountered in initial development and operation of manned space flight vehicles and to establish the design requirements for the first operational vehicle. A contract for the design and construction of the full-scale manned capsule and associated instrumentation and equipment should be let early in 1959 and the initial capsule for preliminary investigations should become available approximately 9 months later.

Booster systems including solid-rocket clusters and liquid systems up to the ICBM size are being procured to provide for a progressive series of unmanned flights at increasing velocities up to orbital speed to refine both the vehicular systems and operational techniques to insure the safety of later manned operations.

Some of these preliminary flights will also utilize lower primates to assess a range of physiological and psychological factors that will be attendant to manned operation. Concurrently an intensive program of pilot training involving centrifuge, pressure chamber, simulator and balloon experiments will be undertaken.

Further extensions of these programs are planned for the fiscal year 1960. During this period it is expected that the first orbital flights of the unmanned full-scale capsules will be achieved and effective techniques developed for the reentry and recovery phases of the operation. If the systems and techniques prove successful, some preliminary flights at suborbital speeds with the manned capsule may be undertaken. Additional vehicle capsules and boosters and associated equipment will be procured for the continuing manned flight experiments in the following year.

During the fiscal year 1960 it is also planned to undertake the development and construction of more refined versions of the vehicle that will offer greater capabilities for performing scientific investigations in space and for providing space path control. A range of analytical studies and model experiments will be undertaken to define the optimum approach to these problems and establish the basic design requirements. Initial development of appropriate vehicles should be undertaken.

The major items to be procured for this project are the satellite capsules. A total of 12 capsules will be delivered during the fiscal year 1960; fiscal year 1959 funds will be used for the design, engineering and early construction phases of these satellites. Boosters for short-range test and qualification flights will also be purchased during the fiscal year 1959 and funds will be committed for the ICBM-boosters required for the first orbital flights. The boosters for the manned orbital flights will be purchased in the fiscal year 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1959 supplemental	Fiscal year 1960
Scientific and technical studies:			
Human factors	$600,000		
Range and recovery	100,000		$300,000
Design studies of advanced systems			1,000,000
Prototypes and operational hardware:			
Capsules	11,500,000	$4,000,000	22,000,000
Boosters	21,861,200	16,000,000	27,700,000
Operations and technical services:			
Flight test operations	1,100,000		9,500,000
Range and recovery	600,000		3,000,000
Pilot training			500,000
Supplies, equipment, repairs, and alterations:			
Large scale and wind tunnel models	400,000		3,400,000
Environmental and functional test equipment for capsules and components	500,000		1,000,000
Data acquisition and handling equipment	300,000	200,000	300,000
Simulators and personnel equipment for human factor research and personnel training	150,000	500,000	500,000
All other items	550,000	50,000	800,000
Total	37,661,200	20,750,000	70,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Space rendezvous techniques:

Fiscal year 1959	0
Fiscal year 1960	$3,000,000

1. OBJECTIVES

To determine system requirements and to develop system components necessary for the accomplishment of contract rendezvous between satellites or space vehicles.

2. JUSTIFICATION

For the conduct of advanced space flight investigations it will be necessary to provide vehicles with a capability for attaining or changing precision orbits or trajectories, and for executing controlled rendezvous in space. Such flight operations are fundamental, for example, to the operation of fixed-altitude and stationary satellites, to the construction of complex vehicles in space, and to the

transfer of personnel and materials in the operation of orbiting space laboratories. The development of such operational capabilities is a basic objective of the NASA space vehicle development program.

3. PROGRAM PHASING

During the fiscal year 1960, it is planned to undertake basic studies to establish effective methods for providing the various required types of vehicular space path control. Preliminary investigations will aslo be undertaken to devise practical components, including referencing, target acquisition, director, propulsion, and control systems associated with such operations. It is expected that the state-of-the-art will also permit the initial design and development of vehicular subsystems necessary for the more elementary maneuvers involved in, for example, the circularization of an elliptical satellite orbit.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Study of space maneuver techniques		$300,000
Preliminary investigation of referencing, target acquisition, director, propulsion, and control system components		700,000
Prototypes and operational hardware: Design, development and construction of satellite orbit-control systems		1,500,000
Supplies, equipment, repairs, and alterations: Components, materials, and simulation equipment required for space path control experiments		500,000
Total		3,000,000

Dr. GLENNAN. I had the privilege, Mr. Chairman, of visiting our headquarters for manned space flight at Langley Research Center earlier this week. We spent a full day there reviewing the program. It is really an exciting program and I think it is going very well, indeed. The amount of money here seems large, and yet, to get on with this with as much vigor as we can, this is one of the highest priority programs in Government at the present time, and in that light, it is not too large.

Senator STENNIS. Yes.

Dr. GLENNAN. The number of flights that will be required, there are some 25 I believe, which are test flights that will be required over the course of the next 19 months in order that we can check out equipment and techniques in some of those flights. It is possible in the ballistic flights, that we would be using these as training flights for some of our astronauts.

Senator STENNIS. I remember that you frankly told us in the beginning of the year that this was going to cost around $200 million.

Dr. GLENNAN. We think this is right, sir.

Senator STENNIS. We commended you then for being frank with us about it.

By the way, I might remark, Dr. Glennan and members of the committee, that I introduced Dr. von Braun to a group of 6,000 people last Thursday at Cleveland, Miss., at the annual festival day at the Delta State College. He spoke for 55 minutes on potential rockets, and he covered the possibilities in this field. It shows how interested people are in this subject.

Dr. GLENNAN. Yes.

Senator STENNIS. That is my main point. They sat there for 55 minutes, giving him rapt attention. He had little spice in it, but

at the same time it was pretty heady. They followed every line and I did, too, even though I had heard all those points before. But I must say it is capturing the imagination of the people.

Dr. GLENNAN. Dr. von Braun is one of our most imaginative scientists as well as one of our most conservative engineers.

Dr. DRYDEN. And, of course, he has an important segment in this program.

Senator STENNIS. Yes, I know. Then it was dramatic, you know, that he was on the side of the Germans in World War II. I pointed that out in introducing him.

Well, I thought you folks might be interested in that, in the public interest that has been taken.

SPACE PROPULSION TECHNOLOGY

Dr. GLENNAN. The next item is "Space propulsion technology."

Senator STENNIS. Excuse me, but were there any questions on Project Mercury? I think we covered that so well previously.

All right, Doctor, proceed.

Dr. GLENNAN. This "Space propulsion technology" category we are attempting to push forward the state of art and the development of new propellants, new vehicular systems, or the basic material out of which those systems will grow.

You will find that we are proposing to spend about $3 million on solid propellent rockets, $5 million on high-energy propellant rockets, using high-energy fuels, liquid fuels. In the very large 1- to 1½-million-pound thrust single-chamber engine we are scheduled to spend about $30 million on that. In the support of the AEC's program on the nuclear rockets, particularly the Rover program, we provide support there for the nonnuclear parts of that effort at a total of $8 million.

Space engines and auxiliary power units, each are at $3 million. The space engine studies are really for new methods of utilizing energy in space and the auxiliary power units, the devices which will provide power on a satellite platform in space or in a deep space probe over a long period of time.

Senator STENNIS. Mention the reasons for your increase, please, Doctor, and also, what are you doing and what is the military doing on this same important matter, and what is the interrelationship between their programs and yours?

Dr. GLENNAN. Could I ask Dr. Dryden to pick that up?

Senator STENNIS. Yes.

Dr. DRYDEN. In the first place, I believe we presented to you or mentioned to you at the hearing on the supplemental that the Advanced Research Projects Agency and ours had formulated a national booster program trying to lay out what rockets both of us need to carry on missions for the future.

It turned out that there were required, as I recall, the five new major developments of which the 1-million- and the 1½-million-pound thrust engine is one, and in another is a program in the Defense Department budget being carried on by Dr. von Braun, known as Saturn which is a cluster of a number of existing engines.

There were some smaller ones, such as the engines for Centaur which we are going to discuss later. I think I will not discuss the whole Centaur program. The engines for Centaur this year are financed by the Defense Department. The whole Centaur project is financed in our budget under another item we will discuss. There are mentioned, I think, three of the engines or two more—one a smaller engine and carrying the propellants, and then the 6,000-pound engine.

There is a program of building blocks of engines which you put together in two stages, three stages, four stages, for particular missions, but made up with only five new engine developments and this program is designed to satisfy the requirements of both the Department of Defense and NASA, and that the division of financing at the moment is that in 1960 all of them are in NASA except the Saturn project which is being carried on by the Defense Department.

Now, let's see—I think we should put into the record these pages 262 through 276 of the justification book. The discussion in the committee report of our eralier hearing are a little scattered on the 1½-million-pound engine, but pages 106 to 117; nuclear rocket engines 80 to 83; space engines, 48 to 54, auxiliary power units, pages 36 to 54, and 63 to 66.

(Pp. 262 through 276, justification for space propulsion technology, are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Solid fuel rockets:

Fiscal year 1959	$700,000
Fiscal year 1960	3,000,000

1. OBJECTIVES

To improve the utility and versatility of solid propellent rockets by (1) developing improved burning grain configurations; (2) devising methods for thrust vectoring; (3) devising methods for thrust modulation and thrust termination; and (4) reducing the weight of inert parts.

2. JUSTIFICATION

As compared to liquid propellent rockets, solid propellent rockets have several inherent advantages. They are storable, reliable, utilize simple operating principles, are generally transportable in a loaded condition, and offer advantages of simple firing techniques for relatively untrained launching crews. Their general characteristics and the ability to manufacture them readily in different sizes makes them attractive for such uses as upper stage boosters, retrorockets, and guidance-correction rockets for space systems.

The utility of solid propellent rockets is limited by a present inability to control thrust during burning, to terminate thrust precisely with a fraction of the charge unburned, to re-ignite after initial burning and to obtain simple thrust directional control. The proposed program will aim at an improvement of each of these deficiencies. In addition, research and development efforts will be aimed at the reduction of the weights of cases, nozzles, throat inserts, and other inert parts, thereby improving the overall efficiency of the solid propellent rocket.

3. PROGRAM PHASING

Studies of the problems and requirements of retrorockets will be initiated in 1959 and continued in 1960. Studies of improved propellent combinations will be initiated in 1960. Prototype rockets having improved construction techniques (lighter weights) will be developed in this time period. Advanced thrust modulating and thrust vectoring systems on small-scale rockets will be started in 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Studies of retrorocket systems	$100,000	$200,000
Studies of high impulse propellants		600,000
Prototypes and operational hardware:		
Advanced-construction rockets	400,000	1,000,000
Advanced thrust modulating and thrust vectoring systems		800,000
Supplies, equipment, repairs, and alterations: Components and materials for experimental investigations	200,000	400,000
Total	700,000	3,000,000

High-energy propellant rockets:

Fiscal year 1959	$7,000,000
Fiscal year 1960	5,000,000

1. OBJECTIVES

To conduct basic investigations of high-energy fuels; to develop medium-size rocket vehicles using these fuels; and to initiate design studies leading to large high-energy rocket vehicles.

2. JUSTIFICATION

Fuels of relatively low energy were used in early rockets, both liquid and solid. The present generation of large rockets uses liquid fuels of moderately high chemical energy such as liquid oxygen and kerosene. A newer class of fuels, of significantly higher energy, has been tested for several years in small, experimental rockets. The most promising of these new fuel components are hydrogen, fluorine, and hydrazine. Through the use of these newer fuels it will be possible to substantially increase the payload carrying capacity of the present generation of large rockets. For example, a two-stage rocket that uses oxygen and kerosene as fuels can put 4,000 pounds in orbit around the earth and can send 750 pounds to Mars. By using hydrogen in place of kerosene in the upper stages only, the payload capability can be increased to 8,000 pounds for the earth satellite and 1,500 pounds for the Mars probe for the same launch weight.

Sufficient experience with the new high-energy fuels has now been obtained to proceed with the development of large engines intended for use in rocket vehicles. Preliminary design of the vehicles will proceed concurrently with the engine development so that a useful product will result.

3. PROGRAM PHASING

Since the oxygen-hydrogen combination is currently considered the most promising high-energy fuel combination for practical use, the development effort using these fuels has been initiated. Strong support is required to maintain a reasonable development schedule on this urgently needed rocket powerplant. The development of a final stage using storable propellants (nitrogen-tetroxide and hydrazine) is to start in 1959. As experimental investigation of the fluorine-hydrogen combination is being continued. Finally, design studies and experiments leading to a hydrogen-oxygen engine of 50,000 to 100,000 pounds thrust will be continued.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Experimental investigation of fluorine and hydrogen as fuels	$1,000,000	$1,700,000
Design studies and experiments leading to a hydrogen-oxygen engine of 50,000 to 100,000 pounds thrust level	1,000,000	1,700,000
Prototypes and operational hardware:		
Development of an upper stage rocket using oxygen and hydrogen as fuels	2,000,000	
Development of an upper stage rocket vehicle using nitrogen-tetroxide and hydrazine as fuels	3,000,000	1,600,000
Total	7,000,000	5,000,000

1,000,000-pound-thrust single-chamber engine:

Fiscal year 1959	$10,000,000
Fiscal year 1960	30,200,000

1. OBJECTIVES

To provide a capability for launching very large payloads by developing a million-pound-thrust single-chamber rocket engine for use in a booster-rocket system. The higher thrusts required for even more advanced space missions will be attained by clustering several of these rocket engines.

2. JUSTIFICATION

For missions aimed at boosting large manned vehicles into orbits around the earth and for missions aimed at delivering large instrumented payloads to the planets, rocket systems having thrust levels significantly greater than the capability of present ICBM boosters are required. Systems based on current ICBM's with high-impulse-propellent upper stages will be able to deliver approximately 8,000 pounds into an earth orbit and approximately 1,500 pounds in a planetary probe. A million-pound rocket first stage with a current ICBM as the second stage and a high-energy-propellent third stage would deliver approximately 15 tons into an earth orbit and 5 tons on various interplanetary missions. Such payloads will be required for advanced manned vehicles orbiting around the earth. A booster of the proposed magnitude is also required for instrumented payloads which will be landed on the near planets to explore and investigate the nature of these planets in detail. For missions aimed at manned flight to various interplanetary objectives, significantly higher thrust levels will be required. These will be attainable by clustering the million-pound-thrust motors to produce a 5- to 6-million-pound total thrust.

3. PROGRAM PHASING

Fiscal year 1959 funds will be used to support component research and design analyses for high thrust rockets. During the fiscal year 1959, a contract will be let for the design, fabrication, and development of the million-pound-thrust rocket. Fabrication of components will be started and will be continued into the fiscal year 1960. The engine is to be completed within 4 years.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Prototypes and operational hardware: Design, fabrication, and development of the million-pound-thrust rocket; fabrication of components	$10,000,000	$30,200,000

Nuclear rocket engines:

Fiscal year 1959	$4,500,000
Fiscal year 1960	8,000,000

1. OBJECTIVES

To develop the nuclear-powered systems that must be used to deliver large payloads to various space objectives. More specifically the objectives are to conduct investigations of reactors suitable for application to nuclear rockets, to develop turbopumps and associated propellant feed equipment, to develop methods of cooling parts that are heated by nuclear as well as by thermal radiation, to develop lightweight shield configurations to protect sensitive equipment and personnel from nuclear radiation, to develop methods of controlling the reactor system, and to investigate other problems associated with operation of nuclear systems.

2. JUSTIFICATION

There are two principal types of nuclear power systems applicable to propulsion devices. The first is the heat-transfer rocket in which a low-molecular-weight gas is heated to high temperature in the nuclear reactor. This high-temperature gas is then expanded through a jet nozzle producing thrust. The second system is one in which the heat generated in the nuclear reactor is converted to electrical energy by some thermal-conversion system. The electrical energy may then be used in a wide variety of ways to produce thrust. For instance, it may be used to accelerate ions to high velocity or it may be used to heat and accelerate a plasma out through a jet nozzle. The first type of nuclear system will be referred to as the nuclear heat-transfer rocket; the second system will be referred to as the nuclear electric rocket.

Nuclear heat-transfer rocket.—Because of the low molecular weight of the gas discharged from the jet nozzle and the high temperature of the gas, the nuclear heat-transfer rocket is capable of achieving specific impulses in the range of 700 to 1,000 seconds as compared with a maximum of about 400 seconds for the high-impulse chemical rockets. These high impulses gives the nuclear rocket the potential of being able to deliver high payloads into an orbit around the earth with a single-stage rocket. For example, it would be expected that a payload of 30,000 pounds could be boosted into an earth orbit with a single-stage nuclear rocket having a takeoff gross weight of about 250,000 pounds. Using chemical rockets to do this same job would require a three-stage vehicle weighing about a million pounds.

These high impulses of the nuclear heat-transfer-rocket systems also offer the potential of delivering large payloads to various interplanetary objectives when this nuclear rocket is used as an upper-stage rocket. For instance, with a takeoff gross weight of 1 million pounds, a payload of 6,500 pounds could be delivered to a Mars orbit with a four-stage chemical rocket. Using the first two stages of this chemical system and adding a nuclear third stage (still giving a gross weight of 1 million pounds) makes it possible to deliver 28,000 pounds into a Mars orbit. In addition, these high impulses permit the use of low-power-reactor systems to carry large payloads from an earth orbit to various interplanetary objectives in nuclear space-heat-transfer rockets.

Nuclear electric rocket.—The nuclear electric rocket will develop extremely high impulse because of the high velocities to which the discharge particles are accelerated. However, the thrust generated will be significantly less than the weight of the system required to generate the electricity so that electrical systems cannot be used to boost a payload from the earth. It is well suited, however, to propelling a vehicle out in space where the thrust is sufficient to permit the vehicle to leave an established earth orbit and travel to interplanetary objectives. For the advanced space missions in which human crews may travel to distant objectives for exploration or other purposes, the nuclear electric rocket is one of the promising propulsion systems.

Because of the NASA mission to develop vehicles capable of carrying the equipment, supplies, and men that may be needed to explore space, it is necessary that the potential of the nuclear-rocket systems be thoroughly evaluated and developed. Because the major obstacles in the way of the development of these rocket systems lie in the reactor, it is necessary that studies aimed at the earliest possible development of high-temperature, lightweight reactors be made. Along with this reactor work, studies must proceed on the other components of the system so that these other components will not delay the final full-scale system tests.

3. PROGRAM PHASING

The program for the fiscal year 1960 is divided into three principal parts in terms of the application of the nuclear power system: (1) Continued support of the Rover program aimed at the development of high-power reactors for earth-satellite booster application; (2) studies of nuclear systems for application to upper-stage or space-heat-transfer rockets; and (3) studies of nuclear power generating system for early application in electrical propulsion systems. In the Rover program, the NASA will continue to support development of the nonnuclear components. For the upper-stage heat-transfer and electric rockets, system-design studies will be made and component fabrication and performance evaluation will be started.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Space nuclear rockets	$1,000,000	$1,500,000
Nuclear electric power generation for propulsion		500,000
Prototypes and operational hardware:		
Rover project (reactor tests)	2,300,000	1,500,000
Space nuclear rocket	1,000,000	2,500,000
Nuclear electric power generation for propulsion		1,500,000
Operations and technical studies: Space nuclear rockets		200,000
Supplies, equipment, repairs, and alterations:		
Rover project	200,000	
Space nuclear rockets		300,000
Total	4,500,000	8,000,000

Space engines:

Fiscal year 1959	$300,000
Fiscal year 1960	3,000,000

1. OBJECTIVES

To carry out analytical and experimental investigations of space propulsion systems for journeys originating from orbit about the earth.

2. JUSTIFICATION

The possible engines for space propulsion vary from the lightweight but low-efficiency types, such as existing chemical rockets that consume a large amount of propellant, to propose types that are very efficient and consume only a small amount of propellant but are also very heavy. For journeys that require very high energies, such as interplanetary flights, the chemical rocket becomes prohibitively heavy. Journeys of this type will require the use of the more efficient space propulsion engines. These engines will, in general, consist of an energy source, conversion equipment, and an accelerator. The energy source may be nuclear, solar, chemical, or other. The nuclear energy sources are discussed under the program entitled "Nuclear Rocket Engines." The space-engines program will be directed at obtaining a high reliability in the conversion equipment and accelerator components and at reducing engine-hardware weight so that either the payload may be increased or higher thrust engines may be used to reduce trip times.

Basic research must be conducted on advanced space engines in order to explore the possibilities of all types, and development work must be started on systems now considered the most feasible in order to reduce their weight. The possibility of direct conversion of nuclear energy to produce a high-velocity jet also exists so that research work must be continued in this field.

3. PROGRAM PHASING

Funds for the fiscal year 1959 will provide for both analytical and experimental studies to determine the capabilities and operating limits of the components of the systems and an evaluation of the overall system to determine the most feasible type for development. Corrosion and mass transfer, for example, will determine the temperature limits to which the engine can be operated.

Funds for the fiscal year 1960 will provide for additional studies and for prototype hardware of certain components that must be built to check out the features of the components and of the entire system. Evaluation and development of this type of hardware will eventually lead to operational engines for space flight.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Power-conversion equipment	$50,000	$800,000
Acceleration equipment	150,000	200,000
Prototypes and operational hardware:		
Power-conversion equipment	50,000	1,100,000
Acceleration equipment	50,000	700,000
Supplies, equipment, repairs, and alterations:		
Power-conversion equipment		100,000
Acceleration equipment		100,000
Total	300,000	3,000,000

Auxiliary power units:

Fiscal year 1959	**$500,000**
Fiscal year 1960	**3,000,000**

1. OBJECTIVES

To develop auxiliary power units to obtain low weight and high reliability for a wide range of power requirements from that now required on existing satellites to that which will be required in advanced interplanetary journeys.

2. JUSTIFICATIONS

Nearly all vehicles to be effective must have auxiliary electric power, in addition to the main propulsion power source, in order to operate the equipment on board. The type of power unit required depends on the rate of power consumption needed and the time for which it must operate. Possible power units vary from lightweight but low-efficiency types suitable for short-time operation to the heavier but more efficient types for long-time operation. In some vehicles the auxiliary power may be supplied by the main propulsion unit. All systems require one or more components to convert an energy source to electric power. The system that results in the lightest weight for a given mission will depend on the weight and efficiency of each of the components so that each must be studied and developed.

Auxiliary power units can, in general, be divided into two categories: (1) The chemical cell type which contains a given total energy and is thereby limited in time of operation depending on the rate at which energy is used, and (2) the solar cell type which is limited in power output depending on the size and distance from the sun but which has an almost indefinite life or time of operation. The nuclear-powered turbogenerator, like the solar cell, has a very long life limited only by the reactor fuel supply, but is capable of being developed to very high power outputs—in the order of megawatts. At the higher powers these units are useful as the power source for the electric space engines.

Existing units are either very limited in operating times when using the chemical cell, or to very low power output when using the solar cells. Initial work will consist of refining these units in order to reduce their weight and increase their power and reliability. These units, can never be developed for missions which require travel to long distances from either the Earth or the Sun. Studies and research will first be made on components leading to advanced nuclear systems. These studies will then be used to determine which units to develop for future interplanetary and interstellar journeys that will be made.

3. PROGRAM PHASING

Funds for the fiscal year 1959 will be used for studies of various systems to determine their limitations and operating characteristics. These studies will consist of analytical investigations and the construction and tests of component parts that are difficult to analyze. Funds for the fiscal year 1960 are requested for the more detailed study of the systems that appear most promising and for the construction of prototype components of the systems to determine their operating characteristics and efficiencies.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Solar collectors and equipment	$100,000	$100,000
Power sources (except nuclear) and associated equipment	50,000	100,000
Power conversion equipment	50,000	100,000
Prototypes and operational hardware:		
Solar collectors and equipment	100,000	1,000,000
Power conversion equipment	200,000	1,500,000
Power sources (except nuclear) and associated equipment		50,000
Supplies, equipment, repairs, and alterations:		
Solar collectors and equipment		50,000
Power conversion equipment		50,000
Power sources (except nuclear) and associated equipment		50,000
Total	500,000	3,000,000

Dr. DRYDEN. It seems to me there was another aspect here to your question that has slipped my mind. You asked about the defense relation?

Senator STENNIS. Yes.

Dr. DRYDEN. Why the increase in it?

Senator STENNIS. Yes.

Dr. DRYDEN. In the case of the 1-million-pound engine which is the first item showing an increase, this again is a project which in the aggregate will cost well over $100 million, and this is the rise in financing as you get into this development more actively.

Senator STENNIS. Well, the general answer to all of them is you are moving further into the program; is that it?

Dr. DRYDEN. That is right, proceeding with the program.

Senator STENNIS. All right; are there any questions on this category? This is a rather large one.

Mr. Lehrer has said that he has conferred with you about these growing programs. If you could give us an estimate of what to expect in the future, without being bound by any particular figure, of course, we would like to have it.

Dr. DRYDEN. Yes; this is contingent on how far the vehicle developments are carried into the future. If we carry the national booster program as it is presently outlined for the next 10 years, there will be an expenditure of $2 billion, or in the order of $2 billion. The high costs are in the vehicles that are further along in this program. The items that you have here carried to completion, I would guess, would be a matter of a few hundred million dollars—something of that order of magnitude.

Dr. GLENNAN. I think I would like to speak to that, Mr. Chairman.

Senator STENNIS. All right, Doctor.

Dr. GLENNAN. Actually, what Dr. Dryden is speaking of here in this long-range, 10-year program is covered under both the vehicle development section which is running this year at $99 million, and the space propulsion technology running at $2 million. Space propulsion technology is the underlying work out of which systems may grow. In order to deal more sensibly and straightforwardly with vehicles themselves, we have laid those out in a vehicle development category which we will come to in a minute.

Senator STENNIS. So the big engine is the only thing that is going to run into larger money?

Dr. GLENNAN. No.

Senator STENNIS. No?

Dr. GLENNAN. No; I can't say that honestly because nuclear rocket engines might, in the course of the next 10 years, run into a substantial amount of money. It is a little hard to say at this time.

Dr. DRYDEN. I think an analogy might be useful, Senator Stennis, for the aircraft and with which you are very familiar. This space propulsion technology deals with engine development and the rest deals with airplanes in which these engines are used. So this item you are now discussing corresponds with engines, plus auxiliary power systems for airplanes.

It is the pieces that you have to have, Mr. Chairman, that someone has said of airplanes before, and that is that the whole performance on the powerplants—for example, the horsepower or thrust that you have, and in the space vehicle field—your ultimate performance is keyed right back to the engines and these engines just must be developed. You don't buy them off the shelf and this item is the engine development program.

Senator STENNIS. This whole space propulsion technology?

Dr. DRYDEN. Yes.

Senator STENNIS. Any other questions on that one?

All right, Doctor; proceed.

SPACE SYSTEMS TECHNOLOGY

Dr. GLENNAN. We now come to space systems technology and at this point, Mr. Chairman, I would like to insert in the record, pages 277 through 283 of the Justification Book, and cite from the committee report, pages 36 to 40.

(Pp. 277 through 283, space systems technology justification, are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Advanced vehicle systems:	
Fiscal year 1959	$500,000
Fscal year 1960	1,500,000

1. OBJECTIVES

To study the problems arising in the development and use of large rocket vehicle systems.

2. JUSTIFICATION

The NASA has initiated a program for the development of a 1-million-pound thrust rocket motor. In addition, other programs are underway for the development of rocket motors suitable for use with high-energy propellants as well as research directed toward providing nuclear reactors for rocket propulsion. Rocket motors represent only one part of the complete booster system. Other factors to be considered included the tanks, structure, type of staging, methods for attitude control, prelaunch fuel handling, and operation of the vehicle. Some or all of these areas of interest must be examined at an early date so that the complete booster system reaches developmental stages on a time scale that will allow earliest possible use of the rocket motors.

3. PROGRAM PHASING

In the fiscal year 1959 predevelopment study contracts will be initiated to study the problems arising in the use of large rocket systems and/or high-energy propellant systems. They will be continued and extended in the fiscal year 1960. Model testing will be started in 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies	$500,000	$1,200,000
Supplies, equipment, repairs, and alterations		300,000
Total	500,000	1,500,000

Booster recovery systems:
Fiscal year 1959 ..... $500,000
Fiscal year 1960 1,500,000

1. OBJECTIVES

To develop vehicles that will be used with high thrust first-stage rockets so that these rocket systems may be recovered and reused after each launching.

2. JUSTIFICATION

As part of its mission to explore space, the NASA is developing large rocket engines which will be capable of delivering large payloads into an earth orbit or which will be used to boost upper stage vehicles for long-range interplanetary missions. For instance, a cluster of the million-pound-thrust rocket engines can be used to deliver a payload of approximately 150,000 pounds into an earth orbit. These clusters will also be required for the proposed manned lunar missions and for the establishment of permanently manned and therefore permanently supplied space stations from which advanced space missions and operations may be carried on.

It is presently estimated that the hardware cost of each of the clusters of million-pound-thrust rocket systems will be at least $45 million. Because of the extensive use that is proposed for the million-pound rocket and because of the large numbers of these rockets that will be required, it is apparent that means must be found to recover the first-stage booster so that it may be reused. The savings in cost of hardware that would be achieved would pay many times over for the cost of developing a booster system that would be recoverable.

3. PROGRAM PHASING

The fiscal year 1959 funds for this program will be directed only at analysis of various systems of recovery that appear feasible. In the fiscal year 1960, design and engineering will be conducted and promising concepts will be evaluated using models in wind tunnel and free flight experiments.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Analysis of feasible systems	$500,000	$300,000
Design and engineering studies		900,000
Supplies, equipment, repairs, and alterations: Models for wind-tunnel and free-flight experiments		300,000
Total	500,000	1,500,000

Orbiting space laboratories:
Fiscal year 1959 .....
Fiscal year 1960 ..... $2,000,000

1. OBJECTIVES

To establish the scientific, technological, and civilian service requirements for orbiting space laboratories; to rationalize and refine the design, construction, and operating technology of orbiting space laboratories; and to provide and utilize such laboratories for the conduct of important specialized investigations and services in space that cannot be effectively accomplished with other vehicles, particularly of the unmanned type.

2. JUSTIFICATION

Current and planned programs for satellite experiments will provide a new wealth of scientific information of the physical environment of the earth. It has become clear, however, that there is a wide range of advanced scientific and technological investigations in space that can be more effectively performed with an orbiting space laboratory. Such laboratories will provide a stabilized platform in space with sufficient room, weight-carrying capacity, supporting instrumentation and equipment, and, as necessary, accommodations for scientists and technicians to perform more specialized and advanced operations than is possible with current types of space vehicles.

In particular, orbiting space laboratories will provide a capability for conducting advanced and extensive astronomical and cosmological investigations where the onboard operating and analytical faculties of man are advantageous. There are, similarly, other broad areas of scientific endeavor involving, for example, the influence of gravitation on biological processes and of high-energy particles on both organic and inorganic substances that warrant investigation and cannot be adequately simulated in eartb laboratories. The space laboratory will also allow the assessment of man's capabilities, requirements, and limitations for performing more complex and extensive space missions.

Space laboratories will be required for the investigation and proof testing of a host of vehicular components and operating techniques required for other advanced space vehicles. Of note are problems concerning the employment of optical and other critical components in a micrometeoritic environment, the influence of radiations on the structural behavior of special materials, the mechanism of vapor-liquid interfaces under zero gravity as related to powerplant boilers and condensers, the feasibility of mechanical construction in space and the general performance evaluation of inertial platforms, referencing and navigation systems, scientific and operational sensors, space rendezvous systems, personnel equipment, and the like.

There are in addition a wide range of potentialities for the development and provision of important civilian services involving meteorology, communications, broadcasting, mapping, and special observation where the orbiting space laboratory will make vital contributions.

3. PROGRAM PHASING

During the fiscal year 1960, a program will be initiated to advance the technology of the design, construction, and operation of orbiting space laboratories. Such a laboratory represents an important application of the manned satellite technology being developed in another program. In order to provide an early capability for advanced geophysical and biological experiments where earth stabilization and vehicle recovery is required, however, it is planned to initiate the development of internal modifications for a capsule of the type being developed in the manned satellite program for use as an unmanned orbiting space laboratory. The modifications will permit substitution of the experimental apparatus and associated instrumentation for the volume and weight normally required for manned operation. Initial development and construction of special subsystems and experimental apparatus for such a vehicle will also be initiated.

Concurrently, investigations will be undertaken to establish the design requirements for a more advanced orbiting space laboratory that will be large enough to accommodate two men together with appropriate scientific laboratory equipment and thereby permit conduct of a wider range of scientific studies in space.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Investigation of vehicular systems and operational techniques for unmanned laboratory experiment		$100,000
Study and development of instrumentation systems and techniques for space laboratories		200,000
Study and preliminary development of advanced space laboratories		600,000
Prototypes and operational hardware:		
Initial design and development of modifications to a manned satellite capsule		300,000
Initial development and construction of space-laboratory apparatus and instrumentation systems		600,000
Supplies, equipment, repairs, and alterations		200,000
Total		2,000,000

Dr. GLENNAN. This calls for advanced vehicles systems and booster recovery systems at $1½ million each, and orbiting space laboratories at $2 million.

Perhaps Mr. Wyatt would speak to these.

Mr. WYATT. In procuring these newer, larger, and consequently more expensive vehicular systems, we want to insure that, in the first place, we can design the best system because, for example, the Nova vehicle as you may recall from the earlier testimony, would be based upon the use of four of these 1½-million-pound thrust engines in the first stage, leading to a vehicle with a total weight of potentially almost 5 million pounds at takeoff.

We need, in the first place, to know how to properly construct such a vehicle to get the greatest economy of structure because this is, as we say, in an order of magnitude larger than any rocket system we have ever built.

We are now building rockets of around ½ million pounds gross weight. Now we are talking about 5 million pounds of weight. Now, do we need new structural methods? One might say that now we are going from the old way of building fuselages from bamboo and wire to where we build them now of pressurized aluminum. This rocket may stand almost 300 feet tall. Obviously, you can't ship it around the country after it is built. So we have to include in our study of the way to build the rocket, a way to actually assemble it on the launch site so we can do major assembly work right on the launch site, and this has to tie in with the structure itself so we can get a lightweight, efficient structure that can still be erected as a major erection job right on the site where it is going to be launched. These are the things we want to begin studies on in the fiscal year 1960 period.

Again, these vehicles are going to be so expensive that we feel it is economically indefensible not to attempt to recover and reuse parts of the vehicle, principally the first stage of the booster and, consequently, we have initiated or started initiation of studies right now and expect to carry them on through the fiscal year 1960 period on how can we recover some of the very expensive components of the first stage of these vehicles, and we expect to be able to do this.

We need to study alternate methods at the moment and look to the way we want to proceed, but if we can do this, why in recovering actually only one or two vehicles, we can more than repay the cost of the plans that are required to accomplish this recovery technique.

This accounts for the $1½ million we propose under the booster recovery.

The third item, the orbiting space laboratory, I discussed with you in the previous testimony and refers very briefly to this:

The reasoning here is that when we go into truly ambitious space flight, that is when we contemplate the period rather far in the future in which we want to send men out to other planets, we are going to have to send out almost perfect vehicles, because contrary to the comic-strip impression, the present state of rocket technology does not permit us to start a rocket on its way to Mars and then turn around some 30,000 miles out and come back just because something has broken.

When we start this vehicle out, it is going to have to complete its intended path. This means everything in it is going to have to work perfectly. Because weight is such a premium, every pound of weight we put in the vehicle requires several hundreds of pounds of thrust on the ground. We cannot carry a lot of spare parts along on the trip. Consequently, it is going to be necessary to examine, and very thoroughly check, the reliability of each of the components that we put into a system of this sort.

We have to examine this reliability in the actual environment in which it is going to operate, and that is the environment of true space, subject to radiation, the reduced pressure which the vacuum of space introduces, the problems of lubrication, weight of the bearings, seizure of the bearings.

We feel one of the ways we want to conduct this preliminary study of components and systems is to put these components into space and keep them there for a substantial period of time in order to get a reliability check. A vehicle to do this we would call an orbiting space laboratory, a laboratory that will be put up and allowed to orbit the earth and either bring the whole laboratory down and examine the specimens in it or resupply it from time to time and leave the laboratory up there and go up and examine what is happening and make changes in the program.

We are requesting some $2 million in the 1960 budget to initiate studies on what are some of the peculiar problems that must be overcome in order to really contemplate the use of orbiting space laboratories. The vehicles that we have in our national vehicle program will give us the potential to put up very large orbiting space laboratories after a period of years. We need now to begin to study the particular problems of how we build these and how we will use these to the fullest advantage. This is the reason for the $2 million request, Mr. Chairman.

Senator STENNIS. All right. Now Senator Young and Senator Cannon are not old enough to remember, but Senator Martin and I remember when you used to take along a 5-gallon can of extra gasoline in the Model T-Ford. You haven't perfected that method of carrying the extra fuel yet, have you?

Mr. WYATT. No, sir; not at the moment.

Senator STENNIS. Now, the recovery of the boosters that you mentioned at the beginning of your statement—are the military services in those studies and categories with you?

Mr. WYATT. They are in those, too. The work we will do will be in coordination with the military programs; that is, we will not be

casting off totally ignoring the military's efforts. This is a field being looked into at the Army Ballistic Missile Agency. There is work underway and we will be supporting and furthering this sort of work.

Specifically, we would like to aim for a recovery system that we can use with our Vega vehicle that will be coming along in a year and a half. We would like to start recovering the first-stage engines of the Vega missile, if we possibly can.

Senator STENNIS. All right; what is your next item, Doctor?

SUPPORTING ACTIVITIES

Dr. GLENNAN. The next item, Mr. Chairman, is "Supporting activities."

I would ask that pages 284 and 285 of the justification book be placed in the record, and I would like to cite from the committee report, page 225.

(Pp. 284 and 285 on the "Supporting activities" justification are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Tracking and data acquisition:

Fiscal year 1959	$3,300,000
Fiscal year 1960	11,500,000

1. OBJECTIVES

To maintain the operation of tracking and data acquisition facilities necessary to the overall space flight program; to develop improved tracking and data acquisition equipment.

2. JUSTIFICATION

The supporting effort on tracking and data acquisition is being planned to provide common operating facilities in these areas for as much of the varied workload as is practicable. In all cases, whether we consider a scientific program using satellites or sounding rockets, a space probe rocket, or a manned satellite experiment, there is a need for tracking units capable of delivering orbital data or position time histories, and telemetering receivers for data transfer. These devices must be properly coordinated by communications links and the data returned to a suitable computing center for rapid data reduction. Without such equipment there would be no point to most of the projected experiments, as there would be no data available for analysis. Each type of test generally brings with it special requirements on instrument performance, making it necessary to include in the design of the station equipment the greatest possible flexibility.

3. PROGRAM PHASING

This program is intimately related to the construction and equipment portion of the budget as it is with that equipment that most of the operations are concerned. In the immediate future the data acquisition and tracking effort will be devoted to the continued operation of the existing IGY optical and radio interferometer networks. It is proposed to establish additional stations with supplemental fiscal year 1959 funds and with the regular fiscal year 1960 funds as discussed under the "Construction and equipment" section of the estimates. Operational contracts are planned under the "Research and development" appropriation title for a number of both the existing and the new stations. Support will be given to groups who have already participated in the IGY program so as to retain experienced personnel in station operations.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies: Studies relating to tracking methods, data reduction and analysis, methods of data transmission and telemetering	$300,000	$800,000
Prototypes and operational hardware: Telemetering receivers, tracking antennas, transmitters and receivers, readout devices and data recorders of new design	600,000	1,500,000
Operations and technical services: For the operation of the Smithsonian optical stations, the minitrack stations, the space probe receiving units, and shipborne facilities	2,000,000	7,500,000
Supplies, equipment, repairs, and alterations: Replacement parts, recording material, miscellaneous equipment, and minor alterations	400,000	1,700,000
Total	3,300,000	11,500,000

Dr. GLENNAN. We have not really had a presentation of this program and I would ask Mr. Buckley, who is head of our Space Flight Operations, to give this presentation to you now.

Senator STENNIS. All right, Mr. Buckley, come around please.

Dr. GLENNAN. Mr. Buckley in his testimony will be covering some of the capital amounts required.

Senator STENNIS. I understand this was not included in the technical presentation before.

All right, Mr. Buckley, we are glad to hear from you.

Mr. BUCKLEY. Mr. Chairman, and gentlemen, during International Geophysical Year, the problem of tracking satellites was considered. The National Science Foundation and the National Academy of Sciences funded a series of tracking stations around the world. Now, the orbits that were envisioned for the IGY were tracks that went across the country at a low angle, 30°, 30° north and south latitude was the furtherest they went.

A series of stations were planned to track IGY satellites within the latitude range of 30° north and 30° south. The first group of stations that we planned was a group of stations with high quality cameras which took very exact pictures of the vehicle out there against a star background.

This net work of stations produced very exact data. It had certain limitations in that it could be used only when the weather was very clear, and, as a matter of fact this determined the places these stations were put, more or less by the same criteria that you have for astronomical observatories. The other limitation of this series of stations was that you could only photograph the vehicle when it was illuminated by the sun and when the sky was in darkness behind it.

This means just before sunrise, for an hour, and just after sunset, for an hour. However this group of stations gave very, very exact data. Now this is the type of records we have, and this film plate was read locally at the various stations. The data was transmitted within a few hours to Cambridge, Mass., to the Smithsonian Astrophysical Laboratory there.

Senator STENNIS. Excuse me—what is this now? Is that an actual photograph of the tracking?

Mr. BUCKLEY. This is a picture of the sky and these are stars, and this is the satellite going across it.

Senator STENNIS. The tracking of the satellite; is it?

Mr. BUCKLEY. Yes, sir, and the astronomers knowing the positions of the various stars can get the exact place where this satellite was at that instant.

This was made at the local station, but the film was brought back to the United States and put in film readers that the astronomers use and a more exact determination of the satellite was made and computers calculated the exact orbit.

Senator STENNIS. May I ask you this: How long have you been able to take photographs, similar to that, of the stars?

Mr. BUCKLEY. Sir, this is a standard astronomy technique, photographing the sky. For instance, at Mount Palomar in the last few years, National Geographic conducted a very extensive survey of all the sky, the most comprehensive survey ever made and it was made on a series of pictures of this sort.

The second series of stations that were started at the time of the International Geophysical Year were a group of radio receiving stations which had an antenna array that gave a very directive beam. You have seen these special antennas on television stations, and so forth, and this special antenna array detected the exact angle from which the radio signal was coming from the station.

These stations were the optical stations, scattered around the world where the satellites could be seen best. They were dispersed around the world and could track during times of twilight, as I mentioned before, just before sunrise and before sunset. However, with the radio type of receiving station, we do not have these limitations. These were placed up and down the 75th meridian and any satellite fired in this 30° orbit here which was contemplated for the IGY series of satellites would pass through this sort of fence. It would be detected as it went through. There are a few other stations added to this vertical line down the 75th meridian. Following the first successful firing at Cape Canaveral, the stations here, Antigua, and over here, South Africa, on the chart gave assurance that the satellite was on its path and proceeding properly and as it went around the earth and came back, it was picked up at San Diego. It was the station there that gave confirmation really, that it had completed one trip of the earth and if you remember in the newspapers at that time, it was a very dramatic thing.

These two networks were then what we started a year ago and when we started in this business.

Senator MARTIN. Mr. Chairman, may I ask a question?

Senator STENNIS. Yes, Senator Martin.

Senator MARTIN. On that Minitrack network, are those stations all under your direction?

Mr. BUCKLEY. Sir, this group here was part of the Vanguard program and we took it over in the early fall last year so they are part of our own network.

Senator STENNIS. They are now part of your network?

Mr. BUCKLEY. Yes, sir; the optical stations are under the Smithsonian Institution and we support this program through a grant. We do not operate that as an inhouse item.

Senator MARTIN. Are there other comparable networks in operation outside your own jurisdiction?

Mr. BUCKLEY. Well, sir, these are the general workhouse networks for us, and, incidentally, the data from these two networks flows into

the computing group and into the various universities and services. All use the data. I will go into a couple of the networks in more detail a little later.

There are certain changes that ought to be made in these networks I have just shown, as is contemplated in the budget. As you remember, the IGY was going to fire only in low orbits at the start of the program, but later the satellites were fired into other orbits such as the 51° orbit here, and north and south firings were made at the Pacific Missile Range. In this case, the vehicle goes down here and up and down this side of the Earth. Four stations are being added to this Minitrack network to increase it from what it was a year ago.

You remember that there are stations here and here on the chart, along this southerly firing from Canaveral, to be sure everything was well. Following that pattern there will be a station here in Newfoundland and one in Western Europe, which may be England when the site survey team finishes choosing the site.

Senator CANNON. Is that one in Alaska and one in the North Central United States?

Mr. BUCKLEY. The one in the North Central United States will help determine if the first orbit of certain satellites is successful. The one in Alaska is the end of the first orbit, roughly for the orbit firing south from the Pacific Missile Range here. It goes down there and then back up on the other side here—Alaska was chosen because it had good communications. The two important conditions are that they have good communications and are in rather friendly territory. Now these are satellites, there were bodies going around the Earth. In addition to those, we are going to fire a space probe that leaves the Earth and will stay in orbit.

As I will show in the next chart here, when a body gets far enough from the Earth it can be seen from a large area on the Earth, and for this reason we chose to use three large tracking stations separated by 120° of longitude. I will put this picture back up again in one moment, but the stations were dispersed around—three of them about 120° apart. After one of these vehicles reaches a point over the Earth's diameter, one of either of these stations can see it. The type of stations that are being used for this purpose are 85-foot diameter antennas. This one is at Goldstone, Calif., and is run by the Jet Propulsion Laboratory.

The signals you get are extremely weak as the body goes out. We tracked a vehicle 400,000 miles in this last year and if we are going to shoot for Mars, we will be tracking for many, many months so that we will be attempting to pick up signals further than any signals picked up so far.

Now the station that you saw in that photograph was in California and our budget here is to put stations in South Africa and Australia. They will be operated to track these vehicles.

Senator STENNIS. Operated to do what?

Mr. BUCKLEY. Operate as a net of stations to track these vehicles that go far out into space.

Senator STENNIS. Senator Cannon?

Senator CANNON. Dr. Glennan, may I ask you if any of these stations will be used by the military services in their programs?

Dr. GLENNAN. Senator Cannon, we have a signed agreement with the Department of Defense on this tracking problem and it provides that we install these stations, and we provide them with services for tracking such objects as they may desire to have tracked. At such time as the traffic becomes more dense than we can handle with a single unit of this sort, then the other agency may come in and put in a separate unit at that time, using the same communications, the same logistics, the same property, the same management. And so this is really well coordinated; that is, our studies with them as we look forward over the years.

Dr. DRYDEN. It might help if I introduced a general remark here and used another analogy which may not be too good, but, for example, this country has transportation lines—you know, airplanes, trains, and buses. Each one serves a particular purpose.

Now if we think about networks, the question was asked how many networks do you have? Well, this becomes somewhat a matter of definition and also adapted to a particular purpose. Any radio station can listen and hear signals. Many amateurs heard sputnik, but ordinarily they had no way of telling direction or anything of the kind. They just heard a signal.

We don't call that a network of any interest here. The Minitrack network will listen to what we call a cooperative satellite, one on which we put a transmitter which transmits on a frequency that we know. These stations are built for that frequency, and they cooperate with us, so to speak. The Minitrack is the worldwide network set up during Vanguard. It is suitable only for things in fairly low orbits. In other words, if you go into these space probes, this network of electronic stations has no application. It is meant for satellites that carry a suitable transmitter.

You cannot, on this network, hear a satellite that carries a transmitter on some other frequency. If we listen to a Russian satellite, we have to change the frequency. This was done in October of 1957, and there was an effort to change these stations over so they could hear the Russians, but this is a specialized network for our scientific and research and development satellites carrying transmitters that we can listen to.

Now we have satellites that don't cooperate, that don't emit anything. The Defense Department has set up, and I don't know whether you are going to show it, Mr. Buckley, but they have across southern Texas transmitters and receivers and you send up a transmission, get a reflection from this body which is up there. It isn't like radar. You can attempt to do this with radar, but it takes a very large radar, indeed, to see a small satellite. By using a certain frequency region and the techniques developed again by the same group that developed the active Minitrack as it is called; we have a passive Minitrack. They call theirs an active one because it has a transmitter and receiver. There is such a network used by our Defense Department to look for satellites which do not emit radiation.

Now, when you come to the deep-space probes you have a totally different problem and these two networks that I mentioned are not useful. Mr. Buckley has described the deep-space-probe network. Now, all of the information from this feeds into Defense. In this one particular case, by agreement with the Defense Department, I be-

lieve we still hope that Defense is putting up one of these three stations; we are putting one in Australia and they were going to put up the other one constituting the deep-space-probe network.

We mentioned the cameras which have a different purpose, for the very precise purpose of taking pictures of the satellites against the stars.

Now we are going to talk later about the man in space. The Minitrack network will not do this job because again the orbit there will be about 100 miles. At 100 miles, it goes by awfully fast, so that you have to have the ability to track this thing more rapidly.

I know all this sounds confusing to you, but I was trying to use the analogy of the transportation system, that you do have many networks; a number of networks are used which are for specific purposes and finally, of course, certainly in the Department of Defense, those who are charged with the defense of the country against ICBM's and so on, you must have systems set up that will distinguish between satellites and missiles, so there is a defense mission.

All of these are tied together in a communications system. This agreement with the Defense Department provided that the communications networks of DOD would be equally available to NASA for transmitting this information back home. For a few of the stations, of course, we have to provide the communication that is not there, but we are using a common network. There are two centers for dealing with the data. Defense is going to have one which is essentially the Defense mission of keeping track of things up there, to distinguish them from missiles. We are feeding off the scientific data we are interested in, but all the data is available to either. This is the setup we worked out with the Defense Department.

Senator STENNIS. Senator Martin?

Senator MARTIN. That answers the question I had a moment or two ago, about duplication.

Dr. DRYDEN. Yes. We think we have it under control, but the confusing part is we must realize there are four or five specialized networks for specialized services just as you have airlines, buslines, trains, all going across the country.

Now, Mr. Buckley, you may continue.

Mr. BUCKLEY. I wanted to close with an explanation of the group of stations that are going to be used for man in space, Project Mercury.

In putting up stations for Project Mercury, the first problem is which way we would fire this capsule and, of course, the basic consideration is the man's safety and the proper place to fire this capsule. This appears to be Cape Canaveral using all their launching facilities.

We want an orbit wherein the same facilities would be used. We also want a concentration of appropriate facilities in the areas where we are trying to recover the man which is even more important because the problem of finding this man and picking him up very quickly out of the water is a very necessary part of this. In the Cape Canaveral area between Norfolk, Charleston, and Jacksonville and Roosevelt Roads and Bermuda, there are always a lot of Navy ships that will help us to recover. That area is highly instrumented with radar to track the man down into the water. You can use the Cape Canaveral facilities and the Navy facilities and the Navy ships in that area for the recovery.

This, then, brought the orbit over Bermuda, across Africa, over Australia where there is quite a lot of equipment there, in the Australian National Range and back adjacent to Hawaii and over near the Pacific Range and across the lower part of the United States.

We don't know whether this man will come down after the first or second or third trip, but in any case, he is over the continental United States, part of the time on all of these, and by firing the group of retrorockets in any of these orbits, we can bring him down in the general recovery area where we plan to have the Navy ships.

Then we have the problem in Mercury to supplement the existing facilities at Cape Canaveral and the Pacific Missile Range and the White Sands, and so forth across the country. We have the same problem with existing facilities in Hawaii, and in Australia, so that we can follow and track this thing and get enough information to know when to fire this rocket, slow it up and bring the man down out of orbit. We also need enough telemetry stations distributed along the path so that we can watch with stations on the ground the heartbeat, respiration, and blood pressure and so forth, of the man in the capsule.

There is a monitoring system within the capsule which holds the carbon dioxide down. In other words, both a mechanical monitoring of the capsule and the doctor's monitoring of telemetered data will doublecheck the proper functioning of capsule all along the Mercury flight path. That is the type of program then that is envisioned for tracking Project Mercury. One thing I want to add is that stations off this course cannot see it. For other groups of stations I talked about, the earth's rotation brought one of the stations in where they can see it tomorrow instead of today.

Now, over here, the longest the vehicle will be up for the early part of the test is 4½ hours, and only the stations along this path can see it. Therefore, you have to choose the path that will use the most stations and add to them as necessary to get the proper information.

Senator STENNIS. That was very interesting, Mr. Buckley, and we thank you.

I want to ask just a few questions and maybe you or Dr. Dryden or Dr. Glennan can answer.

What kind of a tracking system do you now have, like the ones for the Russian lunik probe?

Dr. DRYDEN. We don't know what they had. There were in existence really only two which would have had the ability had they known the frequency in advance to put in the receiving equipment. This is the dish that you saw at Goldstone and the other is a radio-astronomy telescope in Manchester, England. There are perhaps two other places, the Lincoln Laboratory where it is marginal, and whether they could do it at the present time I don't know, but the main point was the Russians did not tell you what frequency they were going to use. When they did announce them over the radio, our Goldstone station worked continuously through the nights and days to put in receiving equipment on the frequency which they said and get it working properly and were able to observe it. They did not track it, since the signal was too weak to operate the automatic tracking of the dish, but what they did do was to have a listener on the radio who did hear signals.

Then the dish was moved around until he said he heard it. When he said he heard it, they recorded it direct and you did get information for some periods. The signals and directions were heard, but those points lie along a curve which went close and, in fact, by the time they were listening, it was past the moon and diverged from the moon.

Later on, the Russians published their observations on the path. I don't know what the equipment used was, but they did publish the path and, when our observations are plotted, they group it in a very small angle around the numbers which they said. Now, neither side had the other's data on it.

Senator STENNIS. Well, did you get enough, though, to show that lunik was an actuality and not a hope?

Dr. DRYDEN. We have no doubt about it whatever.

Senator STENNIS. You are satisfied with that?

Dr. DRYDEN. Yes.

Mr. BUCKLEY. We do know a little bit about the equipment the Russians use for tracking satellites. We have seen pictures of the cameras they have used and also seen a map of a larger number of stations where they have these cameras. This is the method they apparently use. We have seen that. We have also seen pictures of some electronic devices that they have and they look a little peculiar to us, but we have given them careful study. They are a little different from what we expected of them. As a matter of fact, we think they are not anywhere near us in that particular field.

Senator STENNIS. Not near us?

Mr. BUCKLEY. No; not near us. They have put a lot of work on this optical equipment.

Senator STENNIS. Any questions now? Senator Cannon.

Senator CANNON. One question, Doctor. I take it you are not in accord with True magazine?

Dr. GLENNAN. Not at all.

Senator STENNIS. Another subcommittee of the Senate Space Committee recently had General Schriever testifying here. He inserted in the record at my request a statement entitled "Integration of National Facilities for Global R. & D. Tracking."

Are you gentlemen familiar with that statement?

(The statement by Lt. Gen. Bernard Schriever, USAF, entitled "Integration of National Facilities for Global R. & D. Tracking" is as follows:)

INTEGRATION OF NATIONAL FACILITIES FOR GLOBAL R. & D. TRACKING

There are many facilities and systems in existence and under development, both by the military and by NASA, which can contribute significantly to a worldwide tracking and range capability for space research and development. In all cases in which it is technically and administratively feasible, immediate action should be taken to integrate these research and development facilities into an effective global ground environment for space research and development. Facilities of the national ranges which have application to such a global network are those involving tracking and data acquisition, such as radars, optical equipment, and telemetry equipment. With appropriate integration of these facilities in terms of common communications, operating frequencies, and timing systems, the national ranges can function effectively as portions of one overall network.

Such integration and control will rapidly become a large and demanding task, which can be best performed under the executive responsibility of a single mili-

tary service rather than by creation of or expansion of another agency. The Air Forces proposes the establishment within the Department of Defense of a Global Range Control Center which would have the capability and authority for tying together into one global range network those applicable facilities operated by the national ranges, plus such additional facilities as are required. I believe that the Air Force is the service best qualified by experience, resources, and mission responsibilities to perform this executive function, under normal policy guidance and supervision from the Office of the Secretary of Defense.

This Global Range Control Center should be organizationally separate and distinct from the control centers of the national ranges, and should exercise only the control required to coordinate the global aspects of the many research and development activities and demands which will be placed upon it, both by the Department of Defense and by NASA.

As I have earlier stated, the tracking and data acquisition stations of an operational military space weapon system are integral parts of that system. A single global ground environment under a single control agency cannot effectively fulfill all military operational requirements as well as research and development requirements for global surveillance and tracking. The agency responsible for the initial operational capability of a particular system—Sentry, for example—must have the authority to control all elements peculiar to that system (launch, tracking, processing of mission data, communications, recovery, etc.) to insure the integrity and effectiveness of the system as an operational entity. However, it is recognized that minor modifications to these special operational stations may make them capable of accomplishing side benefits which may be utilized by a global agency in furtherance of integrated research and development activities. The control center, therefore, also would require connections with operational complexes—in order to meet research and development needs as well as operational requirements at the earliest possible date. The National Surveillance Coordination Center would provide integrated space surveillance data for both military and NASA requirements, with due consideration of the priority of certain military operations or development objectives.

The Global Range Control Center would be established under an agency of the Air Force, with representation of all using parties concerned. The functions of the control center in integrating the facilities of more than one national range would be as follows:

1. Coordinate global test schedules between national ranges and users;
2. Act as advisers to the national ranges during prelaunch and launch activities;
3. Utilize its centrally integrated resources for the complex computations of orbital and recovery trajectories which will be required;
4. Display research and development global range status and data at all times, providing appropriate information to users; and
5. Maintain an automatic network control.

Dr. DRYDEN. Mr. Buckley says he is familiar with it.

Mr. BUCKLEY. The Air Force came up with a study that advocated an integration plan, I think, ending up in a single filter center through which all the data went through Air Force management.

Senator STENNIS. That is the plan. What is your comment on that, Mr. Buckley?

Mr. BUCKLEY. I think you would have to be careful when you put together these plans that you don't put a limitation on our civilian scientific work in attempting to meet the requirements they would have to have as to security and as to priority and as to saturation in connection with their programs. Their programs demand far more data out of their firings than we do.

Dr. DRYDEN. Mr. Chairman, this is one of the two centers connected into the same series of stations that I mentioned. I think they call it space track and it is the one whose primary function relates to the defense of the country, keeping track of the satellites and distinguishing them from missiles.

We feel that we must, for many reasons, pull the scientific data out into a separate center, although the rest of the system is the same and fully interchangeable between the two centers. There are many considerations. One has been mentioned, and one is security. There are many aspects of this center in Defense that will require security. Take the tracking of the dark satellites for example. That is a defense matter and maybe they want to keep the results of that classified. We have an obligation to do a scientific program with some international cooperation. It will become very difficult for us to do any international cooperation if the facilities are entirely military. This is the reason that we will come to later, that we are able to fire a small satellite at Wallops Island, not a station within Defense. The vehicles we have in mind do not involve ballistic missile boosters and we would then be able to do a certain amount of international cooperation.

There is a further point Mr. Buckley mentioned, that the priority on that matter will have to be on matters relating to defense, whereas we can draw off the same basic data plus the telemetering data from our scientific satellites.

Senator STENNIS. I didn't want to take you by surprise, but I think we ought to call this to your attention and ask you to prepare a comment on it. There is a global range control center which would be established under an agency of the Air Force with representation of all using parties concerned.

Dr. DRYDEN. Could we have that and we will be glad to respond to it?

Senator STENNIS. Yes; and put your comment in later. My only concern here is that we do our duty, as you want to do yours.

(The information supplied to the subcommittee by NASA is as follows:)

Proposals for integration and/or coordination of tracking facilities must be evaluated by considering the national needs, the functions and special purposes of facilities to meet these needs, and what present actions are being taken to coordinate these facilities.

The national needs which have been recognized by the Aeronautics and Space Act of 1958 fall into two categories. One is the security and defense of the country; and the other is the need for a vigorous but peaceful scientific exploration of space.

Facilities to meet these needs are not incompatible nor is it impossible to integrate certain functions or facilities to meet both needs.

In discussing the coordination problem of the tracking and data acquisition facilities used for space programs, it is necessary to keep in mind that various groups of tracking stations result not only from R. & D. alone but also from other quite different requirements.

There is a requirement for intelligence functions to have its own stations which for security reasons may be tightly controlled and so can not be coordinated with other areas. Limited cross-feed of data may be possible, however.

There is requirement for detection or early warning equipment which is special in that it is based on the fact that the satellite is unfriendly and noncooperating; that is, it does not have a special transmitter aboard as do our own satellites. This system must be geared to fact detection, communication, and decision although the data may be of considerably lower quality than needed for R. & D. work. This system can definitely make use of data from other fields.

The third area is that of weapon system classification. General Schriever's testimony stresses the fact that parts of an operational military space system are integral parts of that system and that the agency responsible must have the authority to control all of the elements peculiar to that system, but that minor modifications to the equipment may provide some side benefis for research

and development. The problems of coordination in this area stem from conflict of use, from priority, and from security limitations.

The remaining area, facilities for R. & D. use, consists of stations for military R. & D. and for civilian science programs. However, in some cases, such as Project Transit, the military R. & D. on the project is done with the same tracking and data acquisition system to be later used for the actual weapon system operation phase. This affects the availability and security aspects of the problem.

The stations under the cognizance of the NASA are for an unclassified civilian science program. Most of these stations belong to a net of electronic tracking stations and a net of optical tracking stations which supplement and complement each other and are the workhorses of the satellite tracking program. Almost without exception, every military space firing has made use of data from these stations.

Last fall a coordinating group from DOD and from the NASA had a series of meetings to study the requirements, to assess existing capabilities and to recommend a program. This resulted in an agreement signed by Mr. McElroy and Dr. Glennan on the results of the committee's work, specifying certain additional stations and discussing and specifying the joint use of data from all the stations.

This Joint DOD-NASA Committee has reviewed the current program, and scheduled cross-use of particular facilities.

The complete space tracking facilities program, not just in the R. & D. area but in all the other areas mentioned above, except certain parts of the intelligence area, is under review by this committee. In the short period of its operation this group has done an effective job of matching new requirements of each agency with both capabilities and plans of the other. The group has also taken steps to effect economy in time, effort, and expense through joint discussion and recommendation on operational problems and standardization. Attached are several addenda which set forth the area of responsibility and operational guide lines for the Joint DOD-NASA Committee.

Although this committee has the job of reviewing all tracking and data acquisition plans which are over $250,000, there is a limit to the interchange of data or cross use of facilities which can be accomplished because of the previously mentioned conflict of use, of priorities, and of security. The committee is evaluating all these elements for the Secretary of Defense, and the Administrator of NASA. There is no question that the committee can do a better job of coordination than could a military organization having a heavy missile program and heavy operational weapons system requirements of its own.

ADDENDUM I. AREA OF RESPONSIBILITY OF SPACE FLIGHT GROUND FACILITIES BOARD

The responsibilities of the NASA-DOD committee on space vehicle tracking shall be to study and monitor, on a continuing basis, the national requirements for satellite and space vehicle ground instrumentation for the purpose of insuring an effective and economical national program. In this connection, the committee shall:

1. Review all proposals by government agencies for new ground instrumentation facilities intended for tracking, data acquisition, and communications, where such facilities require establishment of new tracking sites or where a total Government investment of more than $250,000 is involved.
2. Recommend which agency or organization should have responsibility for funding, constructing, and operating ground instrumentation facilities.
3. Review annually the national budget requirements for global tracking, data acquisition, and communications facilities.

ADDENDUM II. OPERATIONAL GUIDELINES

The NASA will fund, construct, and manage facilities needed for tracking, data acquisition, and communications support of scientific or basic R. & D. programs, including facilities needed primarily for support of basic scientific satellites, applied scientific satellites, manned space vehicles, and space probes. The Department of Defense will fund, construct, and manage facilities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States. Within this context, the committee shall be guided in its work by the following policies:

1. New facilities should be built only when the following criteria are met:
(*a*) Existing facilities are inadequate.
(*b*) The space flight programs for which the facilities are required are relatively firm.
(*c*) Adequate study or research and development has been done to indicate that the facility is technically feasible.
2. Sites and facilities should be planned to support as many different programs as practicable.
3. Common site, common logistic support, common communication facilities, etc., shall be used wherever feasible.
4. Site management may be either by DOD or NASA, depending in each instance on consideration such as: which agency has primary need for the site, which agency is best suited to deal with the governmental authorities involved, which agency has land, facilities, or personnel already available, etc.
5. The instrumentation and communications equipment located on a given site shall be owned and operated by the agency which has primary need for the equipment, regardless of which agency manages the site.
6. Each agency shall make available to the other, to the maximum extent feasible, such assistance as may be required in the study, planning, design, development, or operation of its facilities and programs. Each agency shall make the facilities under its control available for support of the other's programs where such support is feasible.
7. In those instances where the NASA-DOD committee cannot reach agreement as to funding or management, the issues shall be clearly outlined and submitted to the Administrator, NASA, and the Secretary of Defense for a decision.

Dr. DRYDEN. One other comment I want to make at this point. This agreement contemplates apparatus owned by NASA and by Defense on the same station.

Senator STENNIS. Yes.

Dr. DRYDEN. Now I have gotten the idea across in other places by pointing out that a dish can look at only one thing at one time. In other words, we cannot be satisfied with a situation where we have only a single dish which may not be available to look at our satellite when it is up there.

Now the networks are the same. The real estate is the same, but we may have equipment on a Defense station and they may have a special piece of equipment on one of the stations that we are managing. The whole thing is tied together in this communications network and you have two places to feed off special classes of information.

Senator STENNIS. All right. Senator Martin, did you have any questions?

Senator MARTIN. I gather from this testimony that this is a point beyond which you cannot go in the elimination of duplication?

Dr. DRYDEN. Yes.

Senator MARTIN. And then there is a point where you must eliminate duplication.

Dr. DRYDEN. There are two jobs to be done. It would be foolish for us to have rival stations all over the world, rival communications. This wouldn't make any sense, but we do say that, since we have a separate job from the military, we may have to put in a special tracking arrangement at any station and get the results communicated and also that we are looking at the mass of data for a different purpose. We have then to do our own computing of it separately from the national defense.

Senator STENNIS. Senator Smith, who couldn't be here just at this moment, was interested in this. I know at the last hearing she said, on page 30 of this year's hearings in February:

Dr. Glennan, you have mentioned the necessity for bringing back to a central distribution point the records collected by the worldwide network of tracking stations.

In view of the point of the variety, what are you doing about the coordinating, the collecting, the collating, and the analyzing of all of this?

Dr. Glennan said:

This is going to be a very real task, actually, because in some of these experiments we get many miles of tape.

The problem is under study at the present time in our organization, how can one perhaps use sampling techniques so that one doesn't have to look at every foot of these tapes.

I just call that to your attention here to get Senator Smith's thinking on the subject and your response thereto, Doctor. Is there anything further that any of you want to add on this before we go to another item?

Dr. GLENNAN. I think not.

Senator STENNIS. All right, then; the next item, please.

VEHICLE DEVELOPMENT

Dr. GLENNAN. The next item, sir, is the vehicle development and at this point, pages 286 through 294 of the justification book should be placed in the record.

Senator STENNIS. All right. The reporter will put those into the record.

Proceed.

(Pp. 286 through 294 of the vehicle development justification are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Fiscal year 1960 estimates

Scout space flight vehicle:

Fiscal year 1959	$6,048,000
Fiscal year 1960	2,000,000

1. OBJECTIVES

To develop a highly reliable, versatile, and inexpensive vehicle to extend capabilities for aerodynamic and space research.

2. JUSTIFICATION

A review of the various scientific experiments to be performed over the next several years has indicated the need for highly versatile, reliable, and inexpensive vehicles which can be launched with minimum facilities and which can be used to conduct a wide range of scientific experiments. These experiments include placing a variety of scientific payloads into 300–500-mile orbits, high-altitude probes, high-velocity reentry tests, advanced heating and ablation studies, and many similar type experiments. A study of the existing available vehicles indicates they are all complex and costly, and not fully optimized for the kind of mission and use described above.

The Scout vehicle is a natural extension and evolution of the multistaged solid-propellant rocket systems that the Langley Research Center has been developing over the last 10 years for high-velocity aerodynamic and reentry research studies. The solid-propellant rocket systems have demonstrated a very high degree of reliability in operation. The systems also combine simplified

logistics and handling inherent in solids so that a reliable and inexpensive vehicle can be achieved.

The Scout vehicle consists of four solid rocket stages whose performance is representative of current advanced state-of-the-art solid propellants. It will have capabilities for launching payloads of 150 to 200 pounds in circular orbits at 300 miles; for placing 100-pound payloads at about 5,000-mile altitudes; for achieving very high velocity reentry (>30,000 ft./sec.); and for use in space target identification and guidance system evaluation.

The use of solid propellant motors, the simplicity of components, and the simplicity of launching and handling techniques will allow launching of the vehicle from a variety of sites including the NASA's Wallops Island station. Handling and launching costs should be greatly reduced.

3. PROGRAM PHASING

There are four major areas of development in the Scout: The propulsion system, the guidance system, the airframe, and the launcher. Contracts for the development of all four areas have been initiated in the fiscal year 1959. Fiscal year 1959 funds will be used for the major phases of development of these components including the procurement of eight sets of propulsion systems, four guidance systems and airframes, and one launcher. Four guidance systems and four airframes will be procured with fiscal year 1960 funds.

It is anticipated that first-vehicle valuation flight test will be conducted in early 1960. Basic vehicle evaluation should be completed by summer of 1960 with the firing of three vehicles. The five remaining vehicles will be used with specific payloads to carry out useful research programs and to obtain data on vehicle performance.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Prototypes and operational hardware:		
Propulsion (includes delivery of 8 units)	$3,400,000	$200,000
Guidance and controls (includes 8 units)	850,000	300,000
Airframe and launcher (includes 8 airframes)	1,500,000	300,000
Operations and technical services: Vehicle flight evaluation		1,000,000
Supplies, equipment, repairs, and alterations: Vehicle and component evaluation	298,000	200,000
Total	6,048,000	2,000,000

Delta space flight vehicle:

Fiscal year 1959	$13,800,000
Fiscal year 1960	13,300,000

1. OBJECTIVES

To provide a reliable interim space flight vehicle for small payload satellites and very small payload space probes, replacing the present Thor-Able, Juno II, Jupiter C, and Vanguard vehicles.

2. JUSTIFICATION

Space projects to date have utilized vehicles that have been adapted from military ballistic missile boosters. While providling valuable interim service, most of these vehicles suffer from technical limitations that restrict their desirability for long-term application as space vehicles.

The Delta space flight vehicle will replace the small-payload vehicles currently in use. It will be similar to the Thor-Able, but will have a coast-phase altitude control system, permitting higher injection altitudes. Delta will be a three-stage vehicle in which the first stage will consist of a production Thor missile with the nose cone and guidance unit removed. The second stage will consist essentially of the Vanguard second stage with an improved radio-inertial guidance system of higher accuracy. The third stage will be a solid-propellant rocket motor developed for Vanguard.

The Delta vehicle will be applied to a number of satellites and space-probe projects. It will have a payload capacity of 300 to 500 pounds for satellite

applications and up to 75 pounds for probe shots to the vicinity of the moon. Delta will be useful for both inclined and polar orbits and will be launched from either the Atlantic or the Pacific Missile Ranges as desired.

3. PROGRAM PHASING

The Delta program is divided into five parts: (1) Fabrication and test of the modified Able second stage; (2) procurement and test of the BTL guidance system; (3) modification of the Thor boosters; (4) integration of the complete Delta; and (5) preparation and launch. Funding for this program, including the procurement of 12 vehicles, will be initiated in fiscal year 1959 and continued in fiscal year 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies: Integration and reliability studies	$500,000	
Prototypes and operational hardware: Thor boosters, 3-stage rockets, vehicle design and manufacturing, and ground service equipment	13,300,000	$8,300,000
Operations and technical services: Range and launching services		5,000,000
Total	13,800,000	13,300,000

Vega space flight vehicle:

Fiscal year 1959	$22,800,000
Fiscal year 1960	42,800,000

1. OBJECTIVES

To provide the first general purpose vehicles in the national space vehicle program. The Vega will be capable of a variety of civil space missions and will also be available as a backup vehicle for several military space missions.

2. JUSTIFICATION

The Vega is intended to be used as either a two- or three-stage vehicle. Some missions, such as Project Mercury, require only two stages while higher performance is required for lunar and space probes. The first stage will be a modified R. and D. Atlas. (The modification will consist principally of changing the forward tank.) The second stage will carry liquid oxygen and kerosene as propellants and will use existing Atlas tooling. The second stage will be powered by the Vanguard first-stage engine, which will be modified to take advantage of altitude operation. The third stage, when used, will utilize storable propellants; this stage is currently under development by the Jet Propulsion Laboratory.

The first launch of the Vega general purpose vehicle is scheduled for the fall of 1960. Its planned payload capability of 5,000 pounds in a 300-mile earth orbit will permit the use of highly sophisticated communications and meteorological satellites. Vega may also be used as a second vehicle in the Project Mercury series to establish a manned orbiting space laboratory capable of supporting two men for several weeks. The Vega vehicle will provide a capacity adequate to permit 800 pounds to be carried to the near vicinity of the Moon. This payload should permit carrying sufficient instruments and transmitting equipment to investigate the Moon's magnetic field and to determine whether or not the Moon is surrounded by radiation belts similar to the Van Allen radiation belts surrounding the Earth. The lunar surface radioactivity and the vestigian atmosphere could also be examined. It should also be possible to employ the Vega to take high-resolution photographs of the hidden far side of the Moon and by an electronic scanning technique, to transfit the resulting photographs to receiving stations on the Earth. Vega is the first vehicle suitable for attempting a close approach to Venus or Mars.

3. PROGRAM PHASING

The Vega program is divided into five parts: (1) Development and testing of the modified Vanguard engine; (2) modification of the Atlas booster; (3) de-

sign and fabrication of the second stage; (4) integration of the Vega vehicle; and (5) testing and launch. Funding for this program, including the procurement of eight vehicles, will be initiated in fiscal year 1959 and continued in fiscal year 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies: Performance analyses and system integration	$2,000,000	$4,500,000
Prototypes and operational hardware: Atlas boosters, 2d- and 3d-stage design and manufacture, and ground service equipment	20,800,000	38,300,000
Total	22,800,000	42,800,000

Centaur space flight vehicle:

Fiscal year 1959	----------
Fiscal year 1960	$41,000,000

1. OBJECTIVES

To develop a general purpose space flight vehicle employing a high-energy fuel in fuel in an upper stage.

2. JUSTIFICATION

The technical direction of Project Centaur, initiated by ARPA in the fall of 1958, will be transferred to NASA on July 1, 1959. Centaur is a two-stage vehicle whose first stage is an R. and D. Atlas missile of the type used in the Vega program. The modified Atlas vehicle consists of an operational Atlas with the cone frustrum portion of the liquid oxygen tank replaced by a cylinder. Changing the forward end of this tank permits the upper stage to be the same diameter as the Atlas vehicle. Between the lower and upper stages is a structural adaptor that is attached permanently to the lower stage. The upper stage is mounted on top of the adapter which is jettisoned with the modified Atlas booster. This high-energy stage is powered by two rocket engines. Sets of hydrogen peroxide rockets are utilized for upper stage attitude control during the coast period. The use of high-performance propellants permits a gain in payload weight of approximately 50 percent over Vega for similar missions. Advanced missions, such as planetary probes, would require the use of a third stage.

The most important application for the Centaur vehicle will be to place a communication relay into an equatorial orbit having a period of 24 hours, to permit the satellite to hover over one spot on the earth's surface. The first six vehicles will be devoted to achieving this end. The early flights will be heavily instrumented and refinements dictated by the results of analysis of early test flight data will be incorporated into the later vehicle configurations. The final equatorial 24-hour circular orbit will require the second-stage engine to be fired a total of three times. The launch direction for the booster phase will be selected so that the early portion of a low-altitude parking orbit will cross the equator. At this point the second firing of the upper-stage engines will increase the vehicle's velocity to place it into a transfer ellipse, the second stage being reoriented so that the third firing will provide the velocity for a circular orbit and a change in plane from the transfer ellipse to the equatorial plane. Centaur will be capable of a lunar soft landing and subsequent investigation of the lunar surface, atmosphere, and internal structure.

3. PROGRAM PHASING

The first flight of Centaur is scheduled for 1961. Development of the vehicle and engine is in progress. The program is in five parts: (1) Design, development, and fabrication of the engine; (2) modification of the Atlas booster; (3) design and fabrication of the second stage; (4) integration and testing of the complete Centaur; and (5) preparation and launching. Funding for this program, including the procurement of six vehicles, will be initiated in fiscal year 1959 and continued in fiscal year 1960.

4. Program costs

	Fiscal year 1959	Fiscal year 1960
Scientific and technical studies:		
Analyses and experiments to prove use of high-energy fuel		$2,500,000
Vehicle design and integration studies		1,500,000
Prototypes and operational hardware: Atlas boosters, 2d-stage vehicle designs and manufacture, and ground service equipment		37,000,000
Total		41,000,000

Dr. GLENNAN. This covers, Senator Stennis, the development of four vehicle systems. They have been discussed in your committee report on pages 16 through 18; pages 215 to 217; pages 24 to 26; and pages 103 to 106.

The Scout we ask for $2 million to complete work on a solid rocket multistage vehicle which will be used principally from our Wallops Island Station. This is a device which should be very substantially cheaper as a launching vehicle for payloads up to, say, 150 to 200 pounds, sometimes known as the poor man's space vehicle.

The Delta has been described before as a more sophisticated Thor-Able vehicle where we have inserted coasting guidance and improved the capability of that rocket to somewhere around 250 to 300 pounds. Development and procurement of some 12 Delta vehicles has been initiated this year with an expenditure of about $13 or $14 million and some additional funds in the neighborhood of $13.3 million are asked for in the next year.

The Vega vehicle is a vehicle which utilizes the first stage of the Vanguard, modified on top of an Atlas with a third stage liquid rocket under development by the Jet Propulsion Laboratory. This is the vehicle which it will finally give us, and we hope within 15 months' time, and the sort of capability which has been demonstrated by the Russians and, indeed, it should be in excess of their capability thus far. It should permit placing about a 5,000 payload in a 300-mile orbit or about 800 miles into the vicinity of the moon. Here we are asking for $42.8 million which should get us along with the development of some eight of these vehicles. Hopefully, the first of these will be in use in the latter part of 1960.

Senator STENNIS. 1960?

Dr. GLENNAN. That is right, sir.

Then the Centaur which is a program which thus far has been under the general direction of the Air Force, will be transferred to us for funding and management purposes as of July 1, this year. This is a program which will go along in consort with and close coordination with the Vega vehicle; the same contractor is used because we are using an Atlas as the base booster. Here, for the first time, we will have a rocket with high energy propellants, with liquid oxygen as the propellant. The sum of $41 million is required to move along with it. This is a vehicle which will have very great importance in the military programs as well as in ours. Indeed, its first significant mission is, I believe, in connection with the communications satellite of the military departments. Here we will have a real, close coordination in a project management team overlooking both the Vega and Centaur vehicles in one.

If there are no further questions on this, I suggest Mr. Wyatt give you an explanation.

Senator STENNIS. All right, Mr. Wyatt, is there anything further you wish to say by way of summary or explanation?

Mr. WYATT. No, sir; I will be available for any questions.

Dr. GLENNAN. Mr. Chairman, there will be somewhat more detailed comment on this in our executive session.

Senator STENNIS. Yes. Mr. Lehrer called my attention to a statement here in the Space Business Daily. It says:

> Russia is willing to export sputnik satellites to the West, according to Deputy Premier Mikoyan, but he says he doubts anyone would want to buy them. In his words, there is no profit in them, only glory.

Now, seriously I thought you might want to buy one of those to see just what he has there.

Dr. DRYDEN. Not much good without the rockets. They have been exhibiting the sputnik itself and our people have pictures of it.

Senator STENNIS. This doesn't propose it go any further than what they have already exhibited.

Dr. DRYDEN. Not as I read it.

Dr. GLENNAN. The sputnik relates to the payload part of it. What we would love to buy from them is the rocket.

Dr. DRYDEN. It would provide means of putting it up and if they would sell it to us——

Senator STENNIS. I saw these sputniks on exhibit in Moscow. I didn't know how far it went. I saw the form, but it's very impressive.

Dr. GLENNAN. It is that.

Senator STENNIS. And I was walking around there looking at three of them with my mouth open, just like everyone else.

Dr. GLENNAN. Was that out at the industrial and agricultural exhibits?

Senator STENNIS. Yes. You say now that what you want is the rocket. Just what do you think of the power unit, and all that? Just what do you think of this quote from Mikoyan and have you followed up on it—have you got it?

Dr. GLENNAN. No, I haven't, but I think we should have it. What is the date of that?

Senator STENNIS. Well, this publicattion is dated May 19, 1959.

Dr. DRYDEN. I haven't read it yet, although it is probably on my desk.

Dr. GLENNAN. We will take a look.

Senator CANNON. I would ask if they had a catalog of those items. [Laughter.]

Senator STENNIS. It certainly could hold possibilities if we had the rocket, but it would seem to me that you would also want to buy the tracking equipment.

Dr. GLENNAN. No; we could take care of that.

Senator STENNIS. I mean you would want to know about theirs, wouldn't you?

Dr. GLENNAN. You could put any kind of frequency device on it.

Dr. DRYDEN. Minitrack only weighs 2 pounds.

Senator STENNIS. All right; we will go into this further, the vehicle development items. We will discuss that in executive session.

I propose, if it is agreeable to the committee that we run until 12:30. Is that all right with you, Doctor?

Dr. GLENNAN. Yes, sir; I think we can cover this construction and equipment program.

CONSTRUCTION AND EQUIPMENT

Dr. GLENNAN. We may now turn to pages 301, 302, and 322 through 397 of the justification book and I will ask Mr. Abbott to discuss that.

If you would put these pages into the record he can then discuss it.

(Pp. 301, 302, and 322 through 397, construction and equipment justification, are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Construction and equipment programs, fiscal years 1959 and 1960

	Fiscal year 1959		Fiscal year 1960, regular estimates
	Appropriated	Supplemental estimates	
Langley Research Center, Hampton, Va.:			
Alterations to the thermal structures tunnel			$745,000
Analytical computing equipment			2,645,000
Conversion of gust tunnel to noise-research laboratory			315,000
Conversion of test cell to noise-test facility			290,000
Heater and vacuum system for gas-dynamics laboratory			585,000
Total	$11,350,000		4,580,000
Ames Research Center, Moffett Field, Calif.:			
Data-reduction center			2,505,000
Mass transfer cooling and aerodynamics facility			4,050,000
Total	3,720,000		6,555,000
Lewis Research Center, Cleveland, Ohio:			
Ion and plasma jet facility			6,000,000
Zero-power reactor			605,000
Inpile loop			250,000
Land acquisition			5,000
Total	7,800,000		6,860,000
High-Speed Flight Station, Edwards, Calif.:			
Building additions			955,000
Analog computing equipment			350,000
Terminal guidance facility			1,500,000
Total			2,805,000
Space Projects Center, Beltsville, Md:			
Central flight-control and range-operations building			3,300,000
Space-sciences laboratory			6,000,000
Instrument construction and installation laboratory			3,700,000
Utility installations			1,000,000
Total	3,937,000		14,000,000
Pilotless Aircraft Station, Wallops Island, Va	21,193,000		
Jet Propulsion Laboratory, Pasadena, Calif.: New facilities, improvements to existing facilities, and approximately 70 acres of land		$9,000,000	
Pacific Missile Range, Point Arguello, Calif.: Launching facilities including flight-vehicle assembly and checkout facility with equipment for special experiments			3,000,000
Various locations:			
Global range tracking and communication facilities and equipment		12,050,000	10,000,000
Facilities for Rover program			2,000,000
Propulsion-development facilities		3,200,000	8,000,000
Total		15,250,000	20,000,000
Total program	48,000,000	24,250,000	57,800,000

Fiscal year 1960 estimates, construction and equipment—Summary

		Estimated cost
Langley Research Center, Hampton, Va		$4,580,000
Alterations to the thermal structures tunnel	$745,000	
Analytical computing equipment	2,645,000	
Conversion of gust tunnel to noise-research laboratory	315,000	
Conversion of test cell to noise-test facility	290,000	
Heater and vacuum system for gas-dynamics laboratory	585,000	
Ames Research Center, Moffett Field, Calif		6,555,000
Data-reduction center	$2,505,000	
Mass transfer cooling and aerodynamics facility	4,050,000	
Lewis Research Center, Cleveland, Ohio		6,860,000
Ion and plasma jet facilities	$6,000,000	
Zero-power reactor	605,000	
Inpile loop	250,000	
Land acquisition	5,000	
High-Speed Flight Station, Edwards, Calif		2,805,000
Building additions	$955,000	
Analog computing equipment	350,000	
Terminal guidance facility	1,500,000	
Space Projects Center, Beltsville, Md		14,000,000
Central flight-control and range-operations building	$3,300,000	
Space-sciences laboratory	6,000,000	
Instrument construction and installation laboratory	3,700,000	
Utility installations	1,000,000	
Pacific Missile Range, Point Arguello, Calif		3,000,000
Launching facilities including flight-vehicle assembly and checkout facility with equipment for special experiments	$3,000,000	
Various locations		20,000,000
Equipment and instrumentation for global ranges	$10,000,000	
Facilities for Rover program	2,000,000	
Propulsion-development facilities	8,000,000	
Total program		57,800,000

Langley Research Center, Fiscal Year 1960 Estimates

ALTERATIONS TO THE THERMAL STRUCTURES TUNNEL

1. Description

This project covers alterations to the diffuser and the nozzle-entrance section of the 9- by 6-foot thermal structures tunnel. The diffuser length will be increased 100 feet and a variable second throat and control equipment will be installed. An additional heat-barrier door will be installed upstream of the two existing heat-barrier doors and a pressure sealing system will be installed in the entrance section at the point where the existing doors fair into the supersonic nozzle.

2. Justification

The present supersonic nozzle produces severe shocks and boundary-layer separation during the transition from subsonic to supersonic flow at the beginning and end of each test run. The excessive loads imposed upon research models during this transition phase have damaged and destroyed expensive research models designed for test in the less severe conditions encountered at supersonic speed. The research utilization of the facility is restricted by this limitation on model design and construction. In addition, the high starting pressure required by the present diffuser results in a minimum dynamic pressure of 3,200 p.s.f. Increased emphasis on structures for hypersonic aircraft and space vehicles requires investigations in the range of dynamic pressures below 3,200 p.s.f. for the establishment of flutter boundaries and in the investi-

gation of the effects of aerodynamic heating on aeroelasticity. The proposed alterations to the diffuser will reduce the severe starting and shutdown transient flow conditions and at the same time extend the operating range of the facility. The reduction of starting-pressure requirements will permit operation at dynamic pressures between 1,300 and 5,000 p.s.f.

The alterations to the nozzle-entrance section will improve the uniformity of temperature distribution of the flow in the test section and thereby improve the test conditions. Also, the operating characteristics of the present heat-barrier doors will be improved and leakage of hot air into the nozzle and test section between test runs will be eliminated.

3. Cost estimate

Nozzle-entrance section alterations	$29,000
Diffuser extension and variable throat	680,000
Diffuser foundations	36,000
Total estimated cost	745,000

4. Construction schedule

Total estimated completion time: 30 months.

ANALYTICAL COMPUTING EQUIPMENT

1. Description

It is proposed to install additional analytical computing equipment in the data-reduction center and to replace existing worn and obsolete equipment. The project includes new analog computer consoles and digital computing equipment. Transmitting and receiving equipment will be installed for wire connections to test facilities, such as simulation devices, at remote locations.

2. Justification

It has become increasingly apparent that the present analog computing facility is inadequate to handle the present research workload. The situation is becoming more critical due to increased emphasis on real time simulation studies and the increased complexity of these simulations. Much of the present equipment is incapable of performing nonlinear operations on a real time basis with sufficient accuracy. The present computing system is not designed for handling large-scale problems efficiently.

The additional analog computer consoles and associated equipment requested in this project are necessary to handle large problems on a real time basis; the equipment will solve equations of motion for a complete six-degree-of-freedom airframe with nonlinear aerodynamics, nonlinear defining equations, and additional degrees of freedom for automatic stabilization and control. More specifically, the equipment is required to handle the complex problems of high-speed airplane and missile stabilization and control in exit and reentry flight conditions. The equipment will also be used in investigations involving mockups of control systems with fixed cockpit simulators as well as with simulation equipment located outside the data-reduction center.

As expansion of existing analog consoles will handle the increasing complexities in heat-transfer and structural-vibration problems, and the increasing workload in such landing-loads projects as impact-landing-gear responses, rough-runway-taxiing problems, and automatic-landing studies.

Repetitive-type analog equipment is ideally suited for rapid optimization of problem parameters occurring, for example, in autopilot investigations. Such studies are relatively slow on the regular analog equipment and do not require the accuracy of regular analog machinery. The project includes the acquisition of repetitive-type equipment to be used for checking out new analog circuits and reducing scaling problems prior to placing a large problem on the regular and more expensive equipment.

Automatic plotting machinery is also needed for plotting digital computer results (trajectories, transient responses, etc.). This machinery will permit a tremendous reduction in manual effort.

Analog-to-digital and digital-to-analog conversion equipment is required to permit the combined use of digital and analog equipment for large projects. Problems of flight interception and navigation and control can be solved very efficiently by the combination of analog and digital machinery. Many equa-

tions, such as axis transformations, are better handled on the digital computer, while the missile or airplane equations of motion are better handled on analog machinery. By the combination of the two computer types, investigation of complex systems can be carried out, obtaining the accuracy of the digital equipment when necessary and still maintaining the speed and flexibility of the analog equipment.

3. Cost estimate

Analog equipment:	
Computer consoles and associated equipment	$1,450,000
Expansion of existing consoles	250,000
Repetitive-type computing equipment	150,000
Wire transmission and receiving equipment	80,000
Total, analog equipment	1,930,000
Digital equipment: Automatic plotting machinery	160,000
Analog-digital converter and associated equipment	500,000
Installation and utilities	55,000
Total estimated cost	2,645,000

4. Construction schedule

Total estimated completion time: 14 months.

CONVERSION OF GUST TUNNEL TO NOISE-RESEARCH LABORATORY

1. Description

This project proposes the conversion of the space now occupied by the gust tunnel to a noise-research test chamber having highly absorbent walls and a working area of approximately 23 by 21 by 21 feet. An air supply of 200 pounds stagnation pressure and a mass flow capability of 25 pounds per second will be provided for the operation of test air jets, both subsonic and supersonic up to 6 inches in diameter and at temperatures up to 1,000° F. An exhaust stack with muffler will be provided for the exhaust air to escape to the outside. A muffled intake system is proposed for scavenging air. Special research instrumentation and air controls are included.

2. Justification

A controlled acoustic environment is of particular need in research requiring low background noise levels and a minimum of reflections, as in transmission studies and in studies of isolation of sensitive equipment. A controlled environment is also needed for studies of such special noise sources as the jet-augmented flap where the noise-radiation patterns are not axially symmetrical.

The proposed modification will make it possible to conduct noise-source studies in the far field on models of jets and rocket engines having exit diameters of up to 3 inches and in the near field on models of jets and rocket engines having exit diameters of up to 6 inches. There would be provisions for studies of the stress responses and transmission phenomena of both plates and shells subjected to random noise in a controlled acoustic environment.

In addition to the capability for handling many important physical acoustics problems, there will also be provided the capability for studies of the effects of noise on man.

3. Cost estimate

Acoustic treatment	$100,000
Air-supply system	34,000
Stagnation pressure control system	69,000
Structural modifications	16,000
Electrical modifications	8,000
Heating and ventilation	7,000
Instrumentation	81,000
Total estimated cost	315,000

4. Construction schedule

Total estimated completion time: 9 months.

CONVERSION OF TEST CELL TO NOISE TEST FACILITY

1. Description

It is proposed to modify a test cell at the internal aerodynamics laboratory, now being used on a part-time basis for noise tests, to a high-intensity-noise facility for research on effects of high-intensity noise on structure and equipment. The project includes the following items:

(*a*) Addition of burning to present cold jet so as to raise noise level from 157 to 170 db.

(*b*) Addition of features for shaping the spectrum of the jet noise and increasing the working test area of maximum intensity from approximately 2 square feet to about 10 square feet.

(*c*) Provision for a siren which would replace the present obsolete siren. The present siren has a capability of 157 db. over a 1-square-foot area. The new siren would have a capability of 175 db. over approximately a 10-square-foot area.

(*d*) Provision of means for testing of structures under conditions of combined noise, high temperatures, and airflow.

(*e*) Provision for additional soundproofing for protection of the operating crew. Present working conditions are poor and border on limits of ear damage for prolonged exposure.

2. Justification

The major purpose of the proposed project is to provide a facility for research on the effects of every high intensity noise on structures and equipment. A secondary purpose is to provide a controlled environment for checking the reliability and fatigue characteristics of components. Both the random-shaped spectrum course and the siren are necessary parts of such a facility, the random noise giving combined overall effects, whereas the siren is a probing tool to find the weak points and a means for conducting accelerated fatigue testing at nominal cost. By carrying on parallel testing programs with both the jet and the siren, research can be conducted on the evaluating of techniques, on methods of equipment isolation and on practices for operating in very high noise levels.

Many failures of aircraft and missiles, including satellite vehicles and ICBM's can be attributed to noise and vibration damage causing malfunction of equipment or failure of the structure. Further basic research which would lead to better design for noise effects is urgently needed. Present facilities for such work are scarce and almost nonexistent. Existing NASA facilities are marginal for the M=0.8 transport requirements and entirely inadequate for dealing with LRI, WS–110A, IRBM, ICBM vehicles, or any sources having afterburners or rockets. The proposed modification would raise the noise levels and provide the flexibility necessary for conducting research in these areas. It would also provide the safety features to protect the operating crew and to maintain an acceptable noise level for the neighbors of the facility. While the proposed modification will not permit large-scale testing of the type required for specific vehicle industrial application, it will permit a sufficient treatment to assure correctness in ultimate application of fundamental concepts as found from theory and basic experimentations.

The proposed modification offers a unique possibility of obtaining a high intensity noise facility in a short time and at nominal cost.

3. Cost estimate

Test cell alteration	$140,000
Test apparatus and instrumentation	150,000
Total estimated cost	290,000

4. Construction schedule

Total estimated completion time: 9 months.

HEATER AND VACUUM SYSTEM FOR GAS DYNAMICS LABORATORY

1. Description

It is recommended that supplementary equipment for the 20-inch jet facilities of the gas dynamics laboratory be provided, as follows:

(*a*) *Heater system.*—An electrical air heater capable of raising the air temperature from 1,050° F. to about 1,500° F. to be installed immediately upstream

of the settling chamber of the 20-inch, M=8.5 tunnel in room 116 of the gas dynamics laboratory.

(*b*) *Vacuum system.*—A vacuum vessel to serve both the Mach 1.5 to 4.5 and Mach 6 20-inch hypersonic jet facilities to be located near room 108, east wing, gas dynamics building, in which the two facilities are located. The connecting line to the M=6 facility will contain an aftercooler. Quick opening valves will be installed in the exhaust lines to enable a switch from vacuum exhaust to atmospheric exhaust during test.

2. Justification

Heater system.—The existing high-temperature, high-pressure air supply in the gas dynamics laboratory is limited to 1,050° F., which is marginal to avoid condensation in the M=8.5 nozzle. To use the existing piping, it is necessary that a gradual pipe heating period of 4 to 5 hours prior to testing be scheduled. The heating must be accomplished with air bleed from the tank farm at a rate of about 10 pounds per second thereby exhausting the daily supply of the gas dynamics laboratory compressed air for just one test run. The proposed heater, by elimination of the presently required preheat bleed air drain, will make possible an increase in average tunnel operating frequency from 1 run per week to 10 or more. It will also permit running when setups are complete without major interference with other facilities using the same air supply in the gas dynamics laboratory. In addition, with the higher air temperatures, it will be possible to use interchangeable nozzles to obtain Mach numbers up to 10.5.

Vacuum system.—Past studies indicate that, even without considering the deleterious effects of aerodynamic heating, flutter can be a critical design consideration at hypersonic speeds. While it appears that aerodynamically the estimation of flutter at these speeds has certain simplification, the nonlinearities in the air forces and the odd configurations and construction contemplated make it urgent that this research be extended to higher Mach numbers. The provision of the proposed system for use with the variable Mach and Mach 6 20-inch jet facilities will permit flutter research in the Mach range of 1.5 to 6.0. The system will also provide the ability to start at the low dynamic pressures necessary to prevent destruction of flutter models and to explore a wide range of dynamic pressures in a given test, thereby establishing the flutter boundary. This will be of considerable importance in the solution of aeroelastic and flutter problems critical to the design of supersonic aircarft and vehicles.

3. Cost estimate

Heater system	$230,000
Vacuum system	355,000
Total estimated cost	585,000

4. Construction schedule

Total estimated completion time: 18 months.

AMES RESEARCH CENTER, FISCAL YEAR 1960 ESTIMATES

DATA REDUCTION CENTER

1. Description

It is proposed that a data reduction center be constructed that will provide the facilities required for the reduction of research data and for the solution of complex theoretical problems. The center will be designed to house the existing digital computers, a large capacity, high-speed general-purpose digital computer to be procured on a rental basis, analog-to-digital converters, certain special-purpose analog and digital computers, and the staff of professional employees and technicians needed to program and operate the various computers. A sketch of the proposed facility is shown on the next page.

A large high-speed digital computer will be acquired on a rental basis with a purchase option. The computer that is contemplated as filling our needs is one which will perform arithmetical operations in either fixed decimal or floating decimal mode, with either single or double precision, on words of 11 decimal digits. The input-output unit will be a program-controlled unit capable of communicating with the memory unit and with the input and output devices, consisting of magnetic drums, magnetic tapes, printers, card readers, and card

punches. In particular, 500,000 words of magnetic drum storage and 1 million words of magnetic tape storage will be provided. The memory unit will consist of magnetic core storage of at least 8 sections, each section having a capacity of 2,500 words. The basic memory access cycle will be not longer than 4 microseconds, and most arithmetical operations will require no more than 3 memory cycles.

A small special-purpose digital computer will be acquired to provide computing service for flight-simulation studies. Analog computers and analog-to-digital converters will also be procured for dynamic studies of aircraft and space-craft control systems.

2. Justification

The increased hourly cost of operating large high-speed tunnels, the trend toward research in which dynamic and transient effects are measured, and the increased complexity of theoretical problems all point to the need for a ditigal computer with a high speed of operation and a large storage and memory capacity. A further need exists for a small special-purpose ditigal computer with limited memory but an even higher speed of operation for direct connection through analog-to-ditigal converters to analog signals from flight simulation equipment. The present proposal is designed to meet these needs.

The existing digital computers at the Ames Research Center consist of two electrodata–204 computers which have been purchased and one IBM–650 which we retain on a rental basis. The basic storage capacity of the 204 is 4,000 words and of the 650 is 2,000 words. The access time of these computers is of the order of 2 milliseconds. Experience with this equipment has demonstrated its great value to the operations of the Ames Research Center, both from the standpoint of saving time and money in tunnel operation and data reduction and also in its ability to treat theoretical problems that would be impossible by hand-computing methods. The mere existence of these electronic computers and experience with their capabilities have engendered proposals for the solution of problems, both theoretical and experimental, that overtax the capabilities of the existing equipment either from the standpoint of capaciy, accuracy, or computing speed.

Significant advances have been made in the development of computers in the last 3 years and it is now possible to procure digital computers having hundreds of times the capacity and 500 to 1,000 times the operating speed of the present equipment. To solve the significant problems that we see in the fields of aerodynamic theory, space technology, and data reduction, such equipment is urgently needed.

It is proposed that a large general-purpose digital computer be acquired on a rental basis. While it would be possible to purchase a computer having the performance specified, it is estimated that the cost would exceed $3 million. The performance and cost of computers is changing so rapidly at the present time that purchase of such a machine is not considered prudent at this time. Within the next calendar year it is known that several new computers will be announced in which the ratio of cost to speed and capacity will be substantially lower than any computer now on the market. It is expected that this trend will continue as advances in electronic components and in computer circuitry design permit greater performance for lower manufacturing cost. The maintenance of a large electronic computer requires a staff of electronic engineers and technicians with highly specialized training. To date we have found it impossible to recruit, train, and retain adequate personnel for this duty. Under a rental contract we are in a position to leave machine maintenance in the hands of the contractor; our experience has indicated this to be a highly desirable arrangement.

Contrasted to the large computer, there is a need for a small, specially designed digital computer. This special-purpose computer is not available on a rental basis. Due to its small memory capacity and its special logic, its maintenance will not present any unusually difficult problems. Analog computers and analog-to-digital converters will be needed for input to this computer for on-line operation.

The project includes a building to provide air-conditioned space with humidity control for the computer and its associated equipment and office space for the operating staff.

3. Cost estimate

Building	$1,260,000
Special-purpose digital computer and analog-to-digital converter	660,000
Air conditioning for electronic computers	160,000
Electrical work, including connection of computer for on-line operation	290,000
Streets, lights, utilities	45,000
Design and engineering services	90,000
Total estimated cost	2,505,000

4. Construction schedule

Total estimated completion time: 14 months.

MASS TRANSFER COOLING AND AERODYNAMICS FACILITY

1. Description

The facility proposed will be a combination of vacuum pumping equipment, electrical arc heaters, and high-pressure storage equipment which, in various combinations, will provide the following three pieces of equipment:

(*a*) A low-Reynolds-number, near-orbit-mach-number tunnel primarily designed for the purpose of measuring forces and moments on complete configurations operating in the low Reynolds number continuum-flow regime typical of that encountered by orbiting and shallow reentry type vehicles.

(*b*) An arc-heated, high-velocity jet primarily designed for the purpose of investigating heating effects encountered in relatively low level (long duration) heat-flux conditions at hypersonic speeds (typical of shallow reentry conditions).

(*c*) An arc-heated, high-heat-flux jet primarily designed for the purpose of investigating heat transfer effects in high-level, short duration, heat-flux conditions at low supersonic mach numbers (to investigate conditions typical of steep reentry).

A sketch of the facility is shown on the following pages. A more detailed description of the major parts of the main facility is presented in the following paragraphs:

Low-Reynolds-number, near-orbital-mach-number tunnel.—This tunnel will produce a 1-foot diameter usable test stream having a mach number range from 10 to 20 and test section pressures from 0.1 to 0.5 millimeter of mercury (giving a Reynolds number range of 10^4 to 10^6 per foot). Replaceable nozzles for a mach number range of from 10 to 20 will be provided. Model support and balance equipment necessary to permit force and moment measurements on complete configurations or parts thereof are included as part of the proposal.

Arc-heated, high-velocity jet.—This jet will produce a test stream of approximately 1-foot to 2-foot diameter at velocities from about 20,000 to 26,000 feet per second. The air supply for this tunnel will be stored at pressures of the order of 3,000 pounds per square inch before passage through the heater. Sufficient capacity for 30 minutes' running time will be provided. The air will be heated by high current-density electric arc heaters, followed by a stagnation chamber with cooled walls, and cooled hypersonic nozzle and diffuser. Several removable nozzles will be supplied to provide streams with different velocities. One stagnation chamber will be suitably equipped to program with time the enthalpy and pressure levels, and a corresponding nozzle will be equipped to simultaneously program the model position along the model axis, so that the model experiences the same time history of both chemical state and heat flux as would exist during reentry.

Arc-heated, high-heat-flux jet.—This jet will produce a test stream of approximately 3-inch diameter with air heated to an energy level that will enable reproduction of heat-flux rates approximating those encountered in a steep atmospheric entry but at reduced mach number. The tunnel will use the same storage air and heater as used in the arc-heated, high-velocity jet. Running time will be primarily a function of electrode and nozzle cooling requirements and will be limited to as low as 10 seconds at the higher pressure, temperature and heat-flux rate conditions. The exhaust of this tunnel will be to atmosphere. The short duration of these tests is typical of conditions in an actual steep reentry and adequate for the experimental needs.

2. Justification

The proposed facility is a combined external aerodynamics and mass transfer cooling facility in which three types of experiments will be conducted: (1) Measurements of force, moment, pressure-distribution, and stability characteristics at near orbital mach numbers and simultaneously low Reynolds numbers, (2) fundamental research on heat transfer and mass transfer cooling systems under steady flow conditions, and (3) evaluation tests of particular mass transfer cooling systems by exposing them to the same enthalpy and heat flux history as would exist during reentry. Justification for the aerodynamic research and the heat transfer and mass transfer cooling research is outlined separately in the paragraphs which follow:

Aerodynamic research.—The aerodynamic research to be conducted will be the investigation of low Reynolds number, hypersonic aerodynamic phenomena which are encountered during shallow entries into the atmosphere. Previous experiments at low Reynolds numbers have been confined to relatively low supersonic Mach numbers. Near conditions of peak heating during a shallow entry (e.g., satellite vehicle with or without lift), the Mach number is about 20 and the corresponding Reynolds numbers are the order of 10^3 to 10^5. This is illustrated in figure 1 on the next page. These relatively low Reynolds numbers are within the continuum-flow regime but when combined with the hypersonic Mach numbers, produce unusually thick boundary layers which modify the flow field and heat transfer. Because essentially no investigations have yet been conducted in this domain where low Reynolds numbers are combined with hypersonic Mach numbers, a large gap exists in present knowledge about the forces, moments, and stability characteristics, as well as the heat transfer to shallow entry vehicles. The low-Reynolds-number, near-orbital-Mach-number tunnel with a heated reservoir can provide much of this information inasmuch as it is capable of duplicating both the Mach number and Reynolds number encountered during shallow entries. It is to be noted that the physiological limitations of human tolerance to deceleration requires that manned entries of orbital vehicles necessarily be along shallow flight paths.

Heat transfer and mass transfer research.—A sizable portion of the thermodynamic states encountered during both shallow entries and steep entries (ballistic vehicles or return interplanetary instrument carriers) can be duplicated as illustrated in figure 2. When reproducing the relatively high heat fluxes corresponding to steep entries the facility would be operated only for the relatively short duration of steep entries (10 seconds, approximately), whereas for the much lower heat fluxes corresponding to shallow entries the facility would be operated for durations the order of 5 to 30 minutes.

Much work is in progress on mass transfer cooling systems inasmuch as they offer the advantages of light weight combined with high effectiveness and inherent simplicity. In order that laboratory tests of such systems be applicable to reentry conditions, it is necessary to duplicate the enthalpy level, the heating rate, and the chemical state of the system (by chemical state is meant the homogeneous gas reactions, the herterogeneous reactions, and the solid-liquid-gas phase transformations). An arc-heated facility duplicates the enthalpy level by employing high reservoir temperatures, and reproduces the convective heating rate by operating at relatively high reservoir pressures. The chemical state is duplicated by operating on the same time scale as exists in flight.

Facilities which reproduce the same enthalpy conditions as are encountered during reentry are of three general types: Those employing hypervelocity guns, those employing shock tubes, and those employing electric arc-heated jets. The first two types duplicate the enthalpy level, but they do so in a test time the order of a very small fraction of a second. The reentry times are much larger, however, ranging from about 15 seconds for steep entries of ballistic and return instrument carriers to about 30 minutes for shallow entries of lifting vehicles (see fig. 3). In order to duplicate the chemical state of a mass transfer cooling system (such as an ablation cooling system) wherein the surface material changes phase and then undergoes further chemical reaction with the air, or a radiation cooling system wherein the surface mass undergoes relatively slow oxidation, the testing time must be at least as long as the time required for the various phase transformations and for the complex chemical reactions to take place. Of three types of facility which produce high enthalpies, the arc-heated jet is the only one certain to provide sufficient time for reproducing these phase transformations and chemical reactions. The relatively long time for observation in the arc-heated jet also makes it possible to measure numerous

AMES RESEARCH CENTER
FISCAL YEAR 1960 ESTIMATES

MASS TRANSFER COOLING AND AERODYNAMICS FACILITY

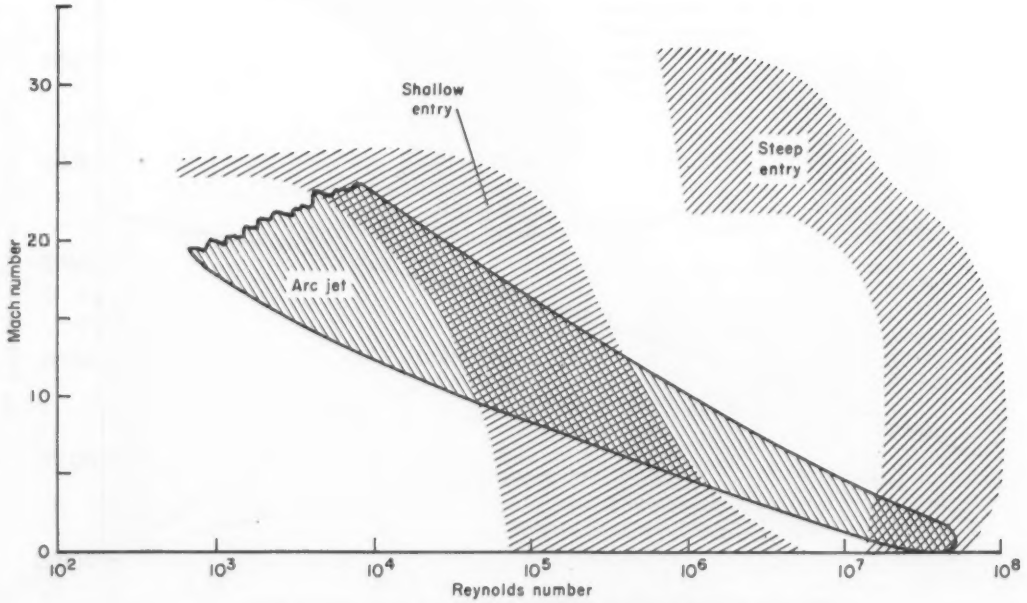


Figure 1 - Comparison of Mach - Reynolds number domain of arc jet with that of shallow and steep entry vehicles.

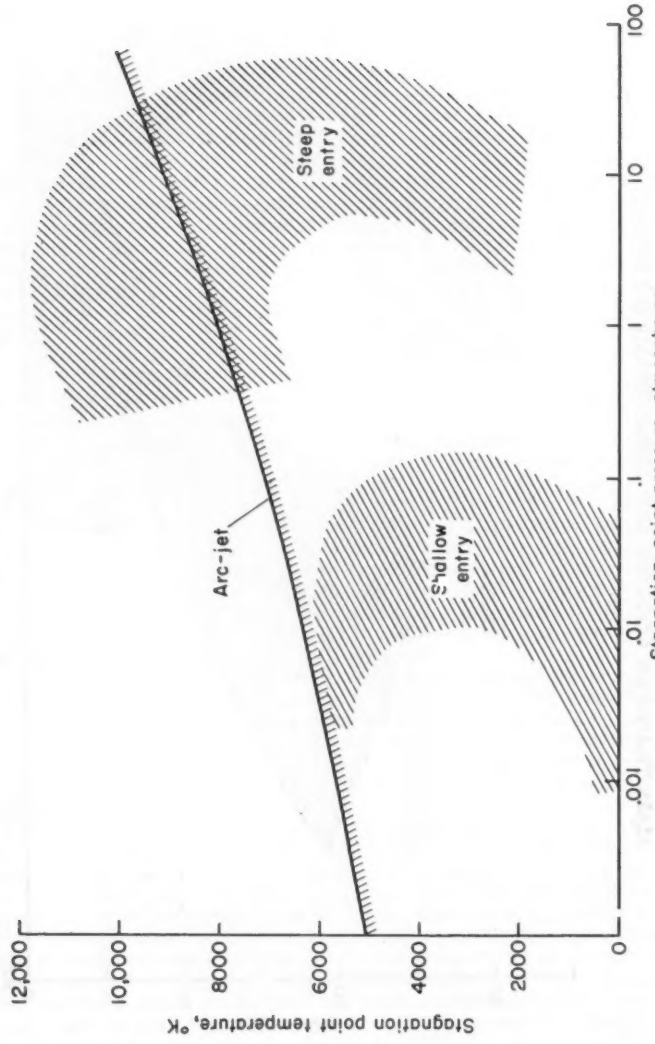


Figure 2. - Comparison of thermodynamic state attainable in arc jet with that encountered by shallow and steep entry vehicles.

AMES RESEARCH CENTER
FISCAL YEAR 1960 ESTIMATES

MASS TRANSFER COOLING AND AERODYNAMICS FACILITY

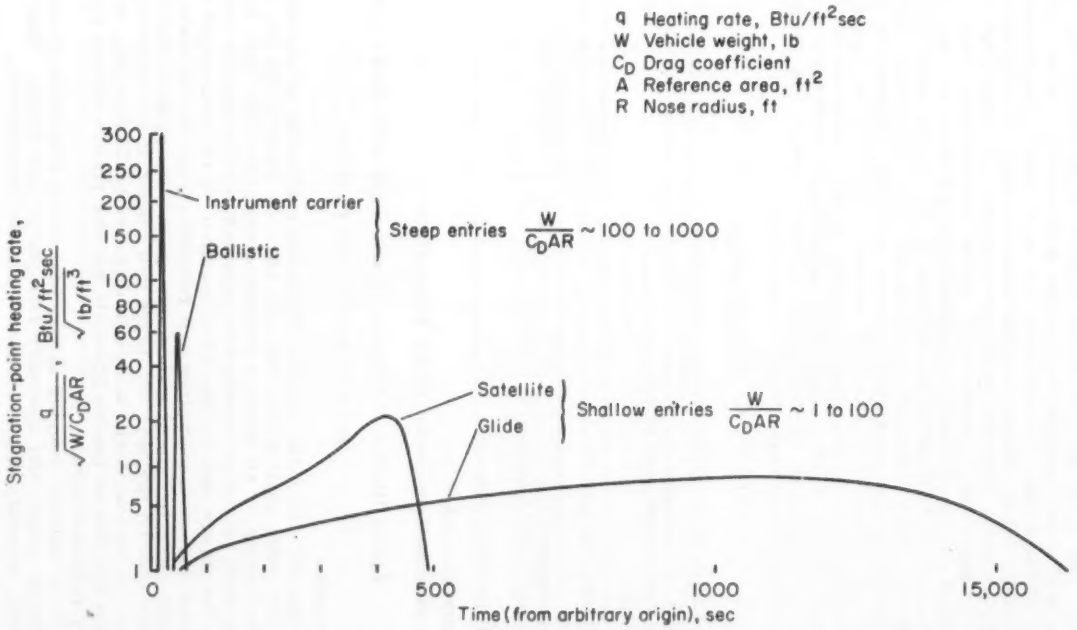


Figure 3. - Heating rates as a function of time for steep and shallow entries

details about the loss of surface material which could not be measured in facilities that operate for only a fraction of a second.

In order to conduct evaluation tests of particular mass transfer systems, the stream stagnation enthalpy and the convective heating rates to the body would be programed in the same manner with time as would exist during reentry. The heating rates as a function of time for typical reentry vehicles are shown in figure 3. The enthalpy would be programed during a run by the combination of controlling the arc current and mixing relatively cold air into the reservoir chamber. The heat flux would be programed by controlling the reservoir pressure and simultaneously moving the position of the model upstream along the axis of the nozzle. In this fashion a mass transfer cooling system can be exposed to the same enthalpy and rate of aerodynamic heating history as would exist during entry into the earth's atmosphere. Although the external aerodynamic characteristics encountered during steep entries cannot be properly investigated by the arc-heated, high-heat-flux jet since the appropriate Mach numbers are not duplicated (as indicated in fig. 1) the mass transfer cooling methods can nevertheless be investigated. This applies to relatively blunt bodies for which the aerodynamic freeze principle applies. As illustrated in figure 1, the approximate Reynolds numbers corresponding to steep entry can be duplicated but it is necessary to operate at Mach numbers much lower than those occurring in flight. These Mach numbers are sufficiently high, however, so that the hypersonic characteristics of blunt bodies can be approximately duplicated insofar as heat transfer is concerned.

3. Cost estimate

High-pressure compressor, storage, and valves	$200,000
Electrical	900,000
Nozzles, test section, and piping	300,000
Arc heaters	300,000
Cooling	200,000
Vacuum tank and pumps	1,000,000
Building	400,000
Instrumentation	500,000
Model programing equipment	250,000
Total estimated cost	4,050,000

4. Construction schedule

Total estimated completion time: 14 months.

LEWIS RESEARCH CENTER, FISCAL YEAR 1960 ESTIMATES

ION AND PLASMA JET FACILITY

1. Description

This facility will make possible full-scale evaluation of electric propulsion devices for some applications and will have the potentiality for expansion to full-scale testing of all electric propulsion devices which have been proposed and for which prototypes should be available in the foreseeable future. It will provide for future installation, when required, of nitrogen-cooled baffles which will permit long-term endurance and reliability tests on full-scale engines and components prior to launching them into space. The proposed facility as shown in the sketches on the next two pages will consist of the following items:

(*a*) A vacuum tank, 50 feet in diameter by 70 feet long, to provide the space required to receive full-scale ion and plasma rockets plus the necessary condenser area.

(*b*) A vacuum pumping system and piping consisting of sixteen 52-inch diffusion pumps and necessary fore pumps and piping. This system will permit operation at pressures as low as 10^{-9} atmospheres.

(*c*) A high-pressure chilled-water cooling system for cooling the vacuum diffusion pumps.

(*d*) A 5 magawatt, 50,000 volt, d.c. electric power supply for research on d.c. ion rockets.

(*e*) Buildings to house the vacuum tank and associated equipment, including a heating plant.

(*f*) An ion rocket propulsion system and instrumentation. This will be a typical flight-type engine which will be used in the first group of experiments.

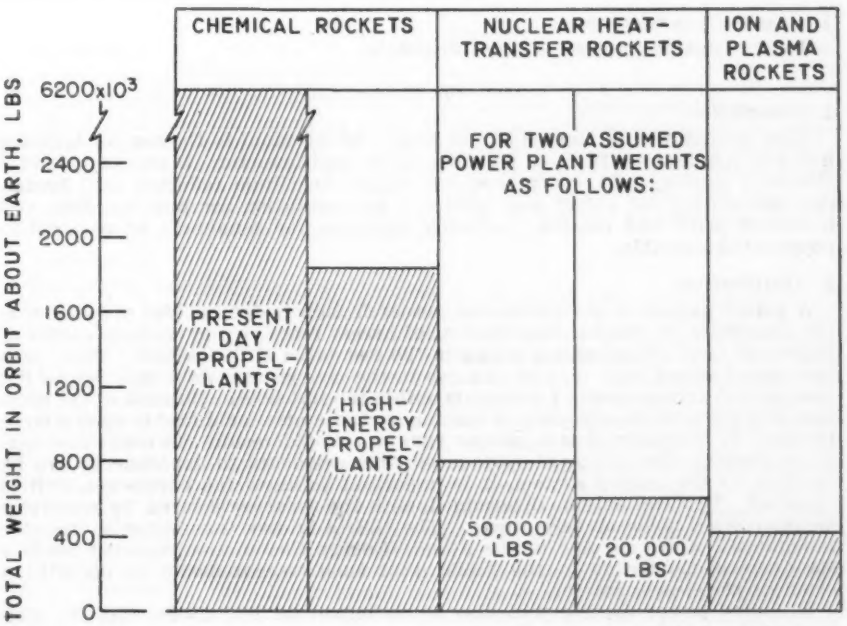
(*g*) The extension of utilities to the site.

2. Justification

Analyses of space missions have shown that ion and plasma rockets offer attractive advantages over chemical rockets and nuclear-heat-transfer rockets for many applications. For example, many types of space vehicles will require large amounts of nuclear-electric or solar-electric power for communication, television relay, data transmission, and internal-environment control. Remarkable weight savings are possible if this electric power can be utilized for the propulsion and control of the vehicle instead of carrying along a separate propulsion system. Applications of electric propulsion of interest within the next few years include the control and stabilization of satellites with astronomical telescopes and television relay systems, and the propulsion of unmanned interplanetary probes. Applications for the more distant future include manned interplanetary expeditions and large-scale freight transfer between the Earth and moon or the Earth and planets. An example of the weight reductions possible for a round trip, eight-man expedition to Mars is shown in the following chart. Even greater weight reductions are possible with technological improvements in powerplant weight.

LEWIS RESEARCH CENTER
FISCAL YEAR 1960 ESTIMATES

ION AND PLASMA JET FACILITY



WEIGHT COMPARISON FOR MARS ROUND TRIP
FOLLOWING MINIMUM-ENERGY FLIGHT PLAN

Facilities now in use, or under construction, at the Lewis Research Center will permit the investigation of small-scale models of ion and plasma rockets. The larger facility proposed herein will provide 10 times the power and vacuum capacity of test facilities now under construction. It will make possible full-scale research on electrical propulsion systems for some applications that seem most promising on the basis of small-scale results. It will have the potentiality for expansion to a capacity suitable for full-scale research on any presently foreseeable electric propulsion system. The durability and reliability of electric propulsion systems can only be established by tests of several years' duration, since most flight applications will require continuous operation for such periods to accomplish a mission. The need for the proposed facility is therefore an immediate one if the Nation's research on space propulsion systems is to proceed at the maximum possible speed.

3. Cost estimate

Vacuum tank, 50 feet in diameter by 70 feet long	$2,000,000
Vacuum pumping system and piping	600,000
High-pressure chilled-water cooling system	250,000
5-megawatt, 50,000 volt, d.c. electric power supply	750,000
Building construction, including heating plant	1,165,000
Ion jet-propulsion system and instrumentation	435,000
Extension of electric power, utilities, and roads	500,000
Design and engineering services	300,000
Total estimated cost	6,000,000

4. Construction schedule

Total estimated completion time: 30 months.

ZERO POWER REACTOR

1. Description

This facility will be located in one section of the canal in the reactor building and will consist essentially of a replica of the main reactor. It will include fuel elements, support grid, control-rod assemblies, beryllium reflector, pool heater, instrumentation for safety and control, instrumentation for flux mapping, and a control panel and console. A bridge spanning the canal will be required to support the assembly.

2. Justification

A major hazard in the component research facility for nuclear propulsion is the possibility of sudden introduction of excess reactivity by various modes of failure of large experimental setups in the test holes of the reactor. These failures could conceivably lead to changes in the composition or to changes in the geometrical arrangement of materials within the test holes. Because of the close coupling between experiment and reactor, such changes could lead to such a large increase in reactivity that a reactor runaway would result. In order to determine whether the effects of various possible accidents to experiments can be handled by the control system, it is important to know the excess reactivities involved. This can only be determined, with the accuracy desired, by reactivity measurements made at zero power. The U.S. Advisory Committee on Reactor Safeguards, which reports to the Atomic Energy Commission, recently made a strong recommendation to the NASA that such measurements be made in a separate zero power reactor.

The zero power facility will also be an important and useful tool for estimating the relative uranium burnup in a partially spent fuel element from the main reactor. This is important for the case of fuel loadings for the main reactor which involve combinations of partially used and fresh fuel elements. Combinations of new and partially spent fuel elements can be used to improve flux distribution and conserve uranium reprocessing. Development work for improvement of nuclear instrumentation and control equipment for the main reactor can also be undertaken with the zero power reactor.

3. Cost estimate

Total estimated cost: $605,000.

4. Construction schedule

Total estimated completion time: 12 months.

INPILE LOOP

1. Description

The first major inpile loop to be inserted into the component research facility for nuclear propulsion will contain a fuel element for a high-temperature gas-cooled reactor. The loop will include the fuel element, compressors to circulate the gas coolant, heat exchangers to remove heat generated within the fuel element, and various instrumentation and safety devices. The objective of the loop tests will be to develop fuel elements for high-temperature reactors. The coolant in the first loop will be helium.

2. Justification

The major function of the component research facility for nuclear propulsion is to do inpile fuel-element research. The possibility of failure of research fuel elements while operating in the facility will exist because of the severe operating conditions required of rocket reactors. In order to prevent damage to the facility the experiment must be made with a fully developed, highly reliable piece of equipment. Experience of other groups indicates that the design, development, construction, and debugging of large loop experiments is a time-consuming process. Construction and development of the first inpile loop experiment must be started as soon as possible.

3. Cost estimate

Total estimated cost: $250,000.

4. Construction schedule

Total estimated completion time: 12 months.

LAND ACQUISITION

1. Description

It is proposed to acquire an additional 25 acres of land adjacent to the Lewis Research Center. The land consists of two parcels. One, identified as Area A in the drawing on the following page, is privately owned and is leased to the Civil Aeronautics Administration. The parcel has an area of 8.6 acres and is occupied by the radio range station serving the Cleveland area. The second parcel, 16.4 acres, is presently a part of the Cleveland Metropolitan Park. It is identified in the drawing as Area B. This land is in the valley formed by Abrams Creek, a tributary of Rocky River.

2. Justification

The NASA was authorized by Congress in the fiscal year 1958 to acquire 115 acres on the north side of Cedar Point Road and west of the present Lewis Research Center property. The extent and location of the property originally requested is shown by the heavy boundary lines in the drawing. All of the land within the boundary lines was proposed for acquisition. However, between the time of the request and the date of the final authorization and the appropriation of funds by the Congress the western portion of the land was allotted, a street was built, utilities were installed, and many private houses were built. As a result of this real estate development, the area identified as area F on the drawing became prohibitively costly and could not be acquired within the appropriation. On the other hand, it developed that area D, not a part of the original request, could be acquired at a very reasonable cost and it was purchased. The property shown as area C has also been purchased.

Area A was previously dropped from consideration as it was leased to the CAA. However, if the CAA does not renew its lease, failure to own land completely surrounded by NASA facilities would very likely cause interference with the center's operations. It is recommended that area A be purchased as a prudent investment to eliminate future problems. The CAA's lease expires on June 30, 1960. However, the lease contains an option to buy the land for $2,500. The CAA has indicated that it does not intend to exercise this option, but will try to renew the lease. Moreover, it has no objection to the NASA acquiring title to the property, provided satisfactory arrangements could be made for the continued occupancy of the property by the CAA for as long as such occupancy is required.

Negotiations are being conducted with the Cleveland Metropolitan Park Board for the acquisition of the property shown as area E under the 115-acre fiscal year 1958 authorization. The director of the board of park commissioners has

informed the Lewis Research Center that the park board will want to dispose of the Abrams Creek valley area (area B) because the land will not be usable for park purposes after they dispose of area E. Area B would be very valuable for future research installations as more and more of the work at the center involves the use of explosive materials. The deep narrow valley would provide a natural safety barrier that would be extremely costly to duplicate in the Cleveland metropolitan area. Being adjacent to existing facilities, the extension of utilities to the area would be relatively simple. Independent appraisals were obtained showing a valuation of $2,500 for area B.

3. Cost estimate

Acquisition of area A, 8.6 acres	$2,500
Acquisition of area B, 16.4 acres	2,500
Total estimated cost	5,000

High-speed Flight Station, Fiscal Year 1960 Estimates

BUILDING ADDITIONS

1. Description

This project proposes the completion of the second floor of the main portion of the HSFS building and the addition of a single-story shop wing. The location and general arrangement of the proposed additions are indicated in the drawing on the following page.

2. Justification

With research aircraft operating at ever-increasing speeds and altitudes there has been and will continue to be a corresponding increase in the complexity of the aircraft, in their supporting equipment, and in the procedures involved in obtaining data from flight experimentation. Consequently, all portions of the station's mission which involve equipment and service space have been growing rapidly and require increases totaling 16,420 square feet of laboratory space and 10,200 square feet of shop area. The two largest groups requiring laboratory space are the data reduction and instrument development groups, which will occupy more than half of the proposed second floor addition. Other groups expanding into this area will include research-engineering and pilot's groups and some supporting research services such as the library. Vacated space will be used to relieve crowded conditions in other research and supporting activities. The proposed shop area will be used to house the relocated machine ship, now occupying space in the hangar which is needed for expansion of the electromechanical controls laboratory; and the instrument shops, including repair, construction, telemetering, and radar. The space now occupied by the instrument shops will continue to be used for that type of work, with some rearrangement to provide more space for instrument calibration. A summary of the current and proposed space distribution follows:

[In square feet]

	Current distribution	Proposed distribution	Change
Laboratory and office areas:			
Office of chief of station	980	980	
Research engineering	5,350	6,860	1,510
Data reduction	3,105	5,665	2,560
Instrument offices and laboratories	9,060	12,745	3,685
Flight operations and maintenance	14,780	17,160	2,380
Administrative services	9,595	10,620	1,025
Research services	2,030	3,090	1,060
Halls and utilities	18,940	23,140	4,200
Shop areas:			
Instrument shops	3,775	9,145	5,370
Machine shop	1,500	2,730	1,230
Shop halls, aisles, and utilities	2,400	4,500	2,100
Electromechanical controls laboratory	900	2,400	1,500
Sheetmetal and welding	3,875	3,875	
Hangar areas:			
Calibration hangar	16,720	16,720	
Main hangar	54,000	54,000	
Total	147,010	173,630	26,620

3. Cost estimate

Structure	$723,000
Plumbing, heating, and air conditioning	101,000
Electrical	80,000
Design and engineering services	51,000
Total estimated cost	955,000

4. Construction schedule

Total estimated completion time: 18 months.

ANALOG COMPUTING EQUIPMENT

1. Description

This project proposes the acquisition of an analog computer assembly similar to that in current use, and an increase in the present computed from 96 amplifiers to 176 amplifiiers.

2. Justification

In order to reduce the number of difficult and expensive X–15 flights, an analog computer assembly is required for use a flight simulator. The proper types of maneuvers for obtaining desired data will be investigated and checked and optimum guidance will be obtained for approaching critical flight conditions. The simulator will also be used for reduction of certain types of data, such as dynamic stability measurements. The new simulator will be used exclusively for flight guidance of the X–15 airplane and will simulate its characteristics as they exist and are known at the time. In this role it will guide the flight program and will be altered only as the airplane is altered or the knowledge of its characteristics changes.

Experience at all NASA activities has shown the analog computer to be an indispensable tool in the conduct of flight research. Through simulator studies of problems connected with flight research, these problems are usually solved more efficiently and quickly. Extension of the flight envelope and development of advanced control and stability augmentation and guidance systems require greater computed capacity so that all the more important system parameters may be included in the simulation. In general this will make any simulation more accurate and realistic. The additional general-purpose computer components outlined in this project will be used for advanced research studies of new systems, vehicles, and concepts and will serve for a large variety of general studies involving both the X–15 and other work at the station.

3. Cost estimate

Flight simulator assembly	$250,000
80 amplifiers and 100 potentiometers	41,000
5 channels of electronic multiplication	16,000
3 resolvers	4,000
Reference voltage supply	2,000
Diode and pot padder function generator	20,000
Digital voltmeter	14,000
Digital voltmeter	3,000
Servo multipliers	14,000
Total estimated cost	350,000

4. Construction schedule

TERMINAL GUIDANCE FACILITY

Total estimated completion time: 8 months.

1. Description

It is proposed to construct a terminal guidance facility to increase the safety of the X–15 operations by assisting in terminal guidance and in chase plane rendezvous. The project includes an acquisition radar with special modification together with suitable ground presentation equipment. A sketch of the facility is shown on the next page.

2. Justification

An important problem area which will be encountered in boost-glide-vehicle operations is that of terminal guidance. In order to provide backup for an onboard navigational system as well as terminal steerage to a specific area, an adequate coverage of the reentry terminal area must be provided. An acquisition radar with the suitable coverage characteristics will provide this capability. Procurement of such equipment for use with X–15 flights will allow a better insight into the problems which will be encountered in actual flights and provide the means of developing terminal guidance techniques. The use of the equipment will also serve to increase the safety of X–15 operations by assisting in terminal guidance and in chase plane rendezvous. The existing radars presently designed into the X–15 range are instrumentation type with extremely narrow beam width and hence unsuited for investigation of the terminal pickup problem.

3. Cost estimate

Structure	$40,000
Radar assembly	750,000
Modification of radar	630,000
Ground presentation equipment	35,000
Design and engineering	45,000
Total estimated cost	1,500,000

4. Construction schedule

Total estimated completion time: 18 months.

SPACE PROJECTS CENTER, FISCAL YEAR 1960 ESTIMATES

CENTRAL FLIGHT CONTROL AND RANGE OPERATIONS BUILDING, SPACE SCIENCES LABORATORY, INSTRUMENT CONSTRUCTION AND INSTALLATION LABORATORY, AND UTILITIES

1. Description

This project proposes the construction of three laboratory-type buildings, the installation of appropriate equipment, and the installation of the necessary utilities. A description of the facilities follows:

(*a*) *Central flight control and range operations building.*—This building will house the personnel and equipment required for monitoring all phases of rocket launchings for global and orbital flights. The information originating at the remotely located launching areas and the global network of tracking stations will be routed to this location for control purposes. Equipment housed will include data readout and conversion apparatus, a large duplex digital computer (rented), automatic reading and plotting machines, and print-out equipment. Associated equipment will include telemetry ground stations, video tape recorders, a time standard device, ground command control transmitters, and backup transmitting equipment.

The first floor will provide space for an industrial and military briefing room, the central range control room, communications staff, and other supporting functions. The basement will house building heating, ventilating, air conditioning, electrical equipment, special computer equipment, air conditioning including humidity control, an auxiliary powerplant, and communication termination equipment. The upper floorspace will house scientific personnel and a library. The building will provide about 60,000 square feet of floorspace.

(*b*) *Space sciences laboratory.*—This building will house scientific personnel for research and development of instrumentation for satellite packages. Studies will be made on infrared radiation, cosmic rays, meteorites, X-ray radiation, magnetic fields, and other geophysical phenomena. The functions of this laboratory will also include the development of vehicle-borne computers and improvement of ground-based computers used to derive detailed orbital or flight path constants of space vehicles. Special equipment will include a magnetically shielded room, particle accelerator, leak detectors, mass spectrometer, vacuum and thermal testing tanks, balancing equipment, centrifuges, shake stands, and gyro and hydraulic test stands.

The first and second floors will provide laboratories for studies in the areas mentioned and offices for the research personnel. The basement will provide space for building heating, ventilating, and electrical equipment, some equipment storage, additional laboratory and office space, as well as a small electronic instrumentation shop. The building will provide about 60,000 square feet of floorspace.

(*c*) *Instrument construction and installation laboratory.*—This structure will consist of shop space for the fabrication and installation of instrumentation and related engineering office space in support of scientific payload research and development. Shop space will be provided for light, precise machine shop work, sheet metalwork, welding and brazing, and bench and floor assembly. A full complement of machine-tool and material-handling equipment is included.

A basement area will house building heating, ventilating, air conditioning, and electrical equipment which will include special air filtering for certain areas including a "clean" room for critical assemblies. The basement will contain a complete photographic laboratory. The building will contain approximately 82,000 square feet.

(*d*) *Utilities.*—These items include the extension of all utilities, site clearing, roads, parking lots, and a central heating plant to provide economical central heating for the center's buildings.

The location plan on the following page indicates the location of the NASA Space Projects Center with respect to Washington, D.C. This is followed by a site plan of the center showing currently authorized facilities and those being proposed in the fiscal year 1960 estimates. Individual drawings of the three new buildings being proposed follow the site plan.

2. Justification

The conduct of a national space-flight program by the NASA requires the construction of a new Space Projects Center from which the technical programs can be planned, monitored, controlled, and evaluated. Initial funding for such a center was provided in the fiscal year 1959 appropriation. The proposed construction for the fiscal year 1960 represents the next phase of the center's development.

The initial construction provides accommodations in 2 buildings for approximately 400 personnel. One building will house scientific, technical, and contracting personnel concerned with theoretical analysis, flight operations, and research-and-development contracting; and provides for the installation of two large digital computers for data reduction and processing functions related to both theoretical work and flight operations. The second building is an office-laboratory for scientific and technical personnel doing research and development on special electronic instrumentation including that required for control and guidance systems.

The construction of a coordinating center for flight operations, including all phases of launching and space flight, is required. The basic elements of a communications system linking together a remote system of firing and tracking stations exists in the Washington, D.C., area. Supervision and coordination of this complex and expanding communications system for the purpose of monitoring data collection and control requires a communications center in the immediate vicinity of the responsible staff. The central flight-control and range-operations building will provide such a center.

Space research conducted by means of rockets, satellites, and space probes is critically dependent on the development of the instrument package to be carried in these vehicles. The problems of making scientifically dependable measurements in space are just beginning to be explored. A space-sciences laboratory is required to house scientific and technical personnel doing this instrument-development work.

An instrument construction and installation laboratory is required to provide effective support to the instrument research and development work. This facility will provide the means for constructing instruments and components and for their installation in satellites and space probes.

Supporting utilities are required to permit effective use of the new buildings. All proposed buildings will provide fallout shelters in accordance with OCDM directive dated September 29, 1958.

3. Cost estimate

Central flight-control and range-operations building:		
Building construction		$1,890,000
Design and engineering services		120,000
Research equipment:		
2 telemetry ground stations	$150,000	
1 ampex video tape recorder	50,000	
1 time-standard device	20,000	
Input-data conversion, data output, and plotting equipment	400,000	
Special-purpose data-reduction units	150,000	
Ground command control transmitters	100,000	
Communications terminal equipment	250,000	
Backup transmitting equipment	200,000	
Provisions for installation of operations digital computer	500,000	
		1,820,000
Total, central flight-control and range-operations building		3,830,000
Space-sciences laboratory:		
Building construction		1,890,000
Design and engineering services		120,000
Research equipment:		
1 magnetically shielded room	$10,000	
6 leak detectors	30,000	
1 particle accelerator	100,000	
1 mass spectrometer	50,000	
4 vacuum test tanks	120,000	
4 thermal test tanks	220,000	
3 balancing machines	90,000	
3 centrifuges	60,000	
2 shake stands	210,000	
4 gyro test stands	255,000	
2 hydraulic test stands	65,000	
Bench equipment for 150 at $15,000	2,250,000	
		3,460,000
Total, space-sciences laboratory		5,470,000
Instrument and installation laboratory:		
Building construction		2,350,000
Design and engineering services		150,000
Research equipment:		
Machine tools (major)	$375,000	
Small machine tools and accessories	800,000	
Photographic-laboratory equipment	25,000	
		1,200,000
Total, instrument and installation laboratory		3,700,000
Utilities:		
Central heating plant		360,000
Electric power and communications		330,000
Roads, site clearing, and drainage		260,000
Water and sanitary sewers		50,000
Total, utilities		1,000,000
Total estimated cost		14,000,000

4. Construction schedule

Total estimated completion time: 26 months.

PACIFIC MISSILE RANGE, FISCAL YEAR 1960 ESTIMATES

LAUNCHING AND SUPPORT FACILITIES

1. Description and justification

The satellites flown to date have been launched in inclined orbits of from approximately 30° to 50° to the Equator. Facilities for such launchings are located at the Atlantic Missile Range at Cape Canaveral, Fla. Many of the future satellite experiments, including scientific measurements and meteorological observations will require that satellites be launched in a polar orbit at 90° to the Equator. Such launchings cannot currently be undertaken at the Atlantic Missile Range because of the danger of dropping boosters on the Carribean islands and the South American mainland. The Pacific Missile Range at Point Arguello, Calif., will permit such polar launchings and will be utilized for this purpose in the NASA satellite program.

Local tracking and range instrumentation will be provided by the Pacific Missile Range. It is the policy of the Pacific Missile Range, however, to require that the launch facilities be paid for by the agency or user that initiates the requirement. Furthermore, supporting facilities, such as shops, offices, and hangars, must be paid for by the user if they are to be for his exclusive use.

The overall NASA satellite program requiring polar launches will include a number of booster configurations. Some of the launch facilities required for Atlas booster configurations will have been installed by other users and will not have to be duplicated by the NASA. The NASA expects to make early firings, however, using booster configurations based on IRBM's for which prior launch facilities will not be available. It will therefore be necessary for the NASA to construct the launch facilities required for these firings.

In order to support the contemplated firing program at Pacific Missile Range, it will be necessary for the NASA to have vehicle assembly hangars, a certain amount of shop and instrumentation equipment, and office space for technical personnel assigned to the firing programs. The anticipated program will be large enough to require full-time occupancy of these facilities by NASA. It will therefore be necessary for the NASA to finance these facilities.

2. Cost estimate

2-pad launching facility suitable for firing vehicles using IRBM booster stages		$1,300,000
2-pad construction	$300,000	
Blockhouse construction	1,000,000	
Supporting facilities		1,700,000
Assembly hangar, shop, and office space	$650,000	
Site preparation, utilities, and roads	550,000	
Instrumentation checkout equipment	420,000	
Test equipment	180,000	
Total estimated cost		3,000,000

VARIOUS LOCATIONS, FISCAL YEAR 1960 ESTIMATES

EQUIPMENT AND INSTRUMENTATION FOR GLOBAL RANGES

1. Description and justification

These funds will be needed to continue the improvement of satellite and space vehicle tracking stations for which funds were requested in the fiscal year 1959 supplemental estimate and to provide additional instrumentation facilities specifically required to support manned satellite experiments.

Improvement of existing electronic and optical tracking stations.—To provide the tracking, data acquisition, and the communication facilities needed to support the more complicated satellite experiments planned for the period beginning 1 to 2 years from now, further modification and improvement of the electronic and optical tracking networks will be required. The funds requested

in this project will provide for a continuation of the antenna and data read-out equipment improvement which was begun with fiscal year 1959 funds. Higher capacity telemetry equipment will also be installed at some of the stations to handle a larger number of satellite programs, and to service a wider bandwidth telemetry data reception.

In addition, the electronic tracking facilities will be supplemented by the provision of improved optical tracking equipment to provide the very-high-precision tracking data needed for geodetic, navigation, and relativistic satellite experiments.

Data acquisition station on Bermuda.—The project includes funds to provide for the establishment of high-gain automatic tracking antenna and its associated radio receiving, recording, and control equipment on Bermuda. This equipment will serve multiple purposes which include reception of telemetry data from rocket and satellite vehicles launched from Wallops Island and Cape Canaveral, acquisition of telemetry data from space vehicles in orbit, and supplementary tracking of space probes.

Facilities for support of manned space vehicles.—Control center systems: Proper execution of the various functions required on a global basis for the launching, flight, reentry, and recovery of a manned satellite system will make necessary the provision of a suitable center for the coordination and control of the complete operation. It is proposed to supplement existing equipment systems to accomplish these functions.

The funds requested herein will be required to provide a voice link to the manned satellite, and modifications to existing equipment for command functions to the satellite. Necessary data transmission terminal equipment with coordinate converters, computers, data recording apparatus, display systems, and control devices would also be provided.

Data acquisition systems: Scientific and operational data generated in a satellite during launching, orbiting flight, and recovery, must be relayed to ground stations for reduction, analysis, and control of subsequent operations.

Funds are included to provide such data acquisition systems for five ground stations and seven shipboard installations, and to supplement existing equipment at five additional ground stations. The systems will include antenna networks, telemetry receivers, data handling equipment, and display devices. Installation will be made at the primary ground stations in the manned satellite network.

Extension of data transmission, communication, and command systems: In order to close major gaps in the ability to coordinate data acquisition and control functions in the network of ground stations for manned satellite operations that were started in the fiscal year 1959, additional equipment will be required at various stations to provide adequate data transmission, voice communication, with other ground stations and the satellite, and command control of satellite functions.

Funds are requested to provide supplementary high-frequency single sideband or ionospheric scatter systems for surface communications, high-frequency and very high frequency transmitters and receivers for voice communications with the satellite, command interrogation systems, and associated antenna and data handling equipment.

2. Cost estimate

Improvement of existing electronic and optical tracking stations		$1,500,000
Optical tracking equipment	$600,000	
Telemetry receiving and recording equipment	150,000	
Antenna arrays: 5 stations, at $50,000 each	250,000	
Digital data read-out equipment: 6 stations, at $26,000 each	156,000	
Instrument buildings: 11 stations, at $25,000 each	275,000	
Test and calibration equipment	69,000	
Data acquisition station on Bermuda		1,355,000
Site preparation and utilities	$335,000	
Basic tracking antenna system	650,000	
Telemetry receiving and recording system	205,000	
Test equipment and spares	165,000	

2. Cost estimate—Continued

Facilities for support of manned space vehicles			$7,145,000
Control center systems		$1,045,000	
Voice link to satellite	$100,000		
Command system modifications	50,000		
Data handling systems	490,000		
Computing facilities	305,000		
Data display equipment	100,000		
Data acquisition systems		4,100,000	
Antenna, telemetery receivers, and data handling and display systems for 5 ground stations	$1,500,000		
Antenna, telemetry receivers, and data handling and display systems for 7 shipboard installations	2,100,000		
Modifications and additions to telemetry systems at 5 existing ground stations	500,000		
Extension of data transmission, communication, and command systems		2,000,000	
Surface communication systems	$1,000,000		
Satellite voice links and command control system	700,000		
Auxiliary equipment	300,000		
Total estimated cost			10,000,000

FACILITIES FOR ROVER PROGRAM

1. Description and justification

Nuclear heat transfer rockets in which a low molecular weight gas is heated to high temperature in a nuclear reactor and then expanded through a jet nozzle to produce thrust, offer large performance gains over chemical rocket systems. The low molecular weight of the discharge gas combined with the high gas temperature in the reactor permit the attainment of impulses for the nuclear system that are approximately twice as high for the nuclear rocket as for the chemical system. This high impulse gives the nuclear rocket the potential of delivering a large payload into an earth orbit with a single stage machine whereas the chemical rocket might require at least two and probably three stages. The Rover program now in process is aimed at the development of small, high temperature, high power reactors for use in high thrust booster rockets. The NASA responsibility in this program is concerned primariiy with the development of a propellent feed system for the KIWI–B reactor tests. A multistage pump is being developed for this purpose.

At the present time, the AEC Nevada test site has facilities for testing the reactor component of the nuclear rocket only. There are no facilities for incorporation of a turbopump in the test facility so that the combination of reactor and flow system dynamics can be simultaneously investigated. There is no way of analyzing these combined dynamics characteristics with sufficient accuracy that safe and reliable system operation can be predicted. It is, therefore, proposed that a nuclear rocket facility be designed and constructed so that reactors can be tested with the turbopump propellent feed system that will be used in the full scale nuclear heat transfer rocket. Because the dynamics of the reactor and flow system are not known, it is essential that the early tests of the reactor and the pump be made with a pump drive that has extremely accurate speed control. The only sufficiently satisfactory system is an electric drive system. The present facility will, therefore, supply an electric motor pump drive and required electronic speed control equipment for the early tests. When the dynamics of this system have been analyzed, the reactor will be tested with the full-scale turbopump and the turbine drive gas generator system or the full-flow turbine drive gas system so that the nuclear rocket steady state and transient operation may be accurately evaluated and desirable performance obtained.

This project will supply the electrical drive motor, a variable speed coupling, required speed control equipment, flow controls, the necessary gear boxes to deliver the required pump speed, the turbopump stand, the required gas generator system, the additional liquid hydrogen storage capacity, the required ducting to permit closely coupled reactor-turbopump operation, and the necessary building to house the drive and control equipment.

2. Cost estimate

Facility design and site preparation	$100,000
Cost and installation of electrical drive equipment	500,000
Construction of butler-type building with required foundation mounting for electric motor and turbopump facilities	150,000
Gas generator installation	350,000
Ducting and powerline connections	200,000
Remote electrical and flow control setup	300,000
Propellant storage capacity	200,000
Instrumentation	200,000
Total estimated cost	2,000,000

PROPULSION DEVELOPMENT FACILITIES

1. Description and justification

The names "Vega" and "Centaur" have been given to two proposed space flight vehicles using the Atlas missile as a first-stage booster and incorporating new upper stages. These vehicles are described on pages 291 through 294. Development and flight readiness firings of the new Vega and Centaur second stages will require the construction of two captive test stands, one for each program. In order to meet program schedules funding for the stands is required early in the fiscal year 1960.

An extensive survey of existing test stands which might be modified for these programs and possible sites for new stands is nearing completion. To be acceptable, locations must meet satisfactory standards of availability, safety, and operating efficiency. Beyond these basic requirements the principal yardstick will be minimum total cost of constructing, equipping, and operating the stands. Based on these criteria the most promising solution which has been studied so far is the erection of two new stands at Sycamore Canyon, a Government-owned Atlas test location sufficiently isolated from a hazard standpoint.

In addition to the aforementioned test stands, funds are required in the fiscal year 1960 to make a start toward a new central facility to permit an accelerated research and exploratory development effort in two additional areas of great future importance to the national space effort. Future space missions will necessitate the development of rocket engines that use high-energy liquid propellants. The advantages of the high-energy liquid propellants lie in their potentially high values of specific impulse. Solid propellant rocket engines, which produce relatively lower impulses, have important application in space missions due to their low structural and equipment weight, simplicity, and reliability.

Many of the high-energy propellants (e.g., fluorine) are extremely toxic, corrosive, and reactive. Consequently, current research facilities (NASA Lewis Research Center and the Jet Propulsion Laboratory) are severely restricted in the testing of these propellants because of their proximity to urban areas. A specialized facility located in an isolated area is therefore required. This project will provide such facilities. The facilities will be used initially for the continuation of high-energy propellent work of both the Lewis Research Center and the Jet Propulsion Laboratory on an expanded scale of thrust and number of firings. These facilities will also be used in future development projects. The requirements of the facility are dictated largely by the hazardous nature of propellants to be investigated. Therefore, it is necessary that an isolated site be chosen and that individual facilities be adequately dispersed for efficient and safe operation.

At a Government-owned location to be determined from further studies, facilities will be provided for advanced research and development on both solid and liquid propellant rockets. The funds requested in the fiscal year 1960 will provide for initial site development and for one test stand to accommodate 100,000-pound thrust rocket engines using high-energy propellants.

2. Cost estimate

Vega captive stand: Stand, including mounting tower and equipment for handling, control, and date acquisition		$1,500,000
Centaur captive stand: Stand, including mounting tower and equipment for handling, control, and date acquisition		1,750,000
Central facility for high-energy solid and liquid rocket propellant research		4,750,000
Central assembly shops, offices, and service buildings	$500,000	
Water system (1,000,000 gals. per day)	600,000	
Electrical power to remote site and distribution (10,000 kv.-a.)	1,000,000	
Roads and fencing	600,000	
Communications: Central date recording and processing systems, telephone systems	200,000	
Site preparations: Grading, drainage, and trenches	300,000	
Fluorine-hydrogen rocket facility, 1 test cell only	1,550,000	
Total estimated cost		8,000,000

Mr. ABBOTT. Mr. Chairman, the first item on page 322 is the alteration to the thermal structures tunnel at our Langley, Va., station at a price of $745,000.

This thermal structures tunnel at Langley has been a very useful workhorse for making tests of large-size structural elements or complete missiles of moderate size, including both the airloads and the thermal effects up to a mach number of about three times the speed of sound.

We are asking here for alterations to this tunnel to provide increased altitude simulation and also to decrease the large loads that are experienced by the models in starting and stopping.

These large loads frequently destroy the models which are expensive and also effectively prevent us from making tests on some models which duplicate the actual strength that would be needed for high-altitude vehicles because they would be destroyed in the starting of the tunnel. This prevents us from investigating at the present time certain aerolastic problems. This amount is requested to correct these deficiencies in these pieces of equipment.

Dr. GLENNAN. May I interrupt? In what detail do you want to go into this?

Senator STENNIS. I was just going to say that we don't know the necessity of these items. You come here and say you need a total of $4½ million at the Langley Research Center for them. If this is necessary, we approve it. We just want to know if it has been thoroughly considered and is essential.

Dr. GLENNAN. I think in connection with all of these items of construction and equipment, these relate to an investment in cost new of about $390 million in our own research centers. This is really an austerity program.

Senator STENNIS. Yes.

Dr. GLENNAN. In keeping those centers up to date, in providing the kind of equipment that is necessary in order that they may be kept up to date.

I think you will find in the small blue-covered pamphlet which gives you values of our stations, some detail there which gives you the value and the construction program for 1959 and 1960, and unless you do want to go into great detail on these, we might take out just one or two and point those out to give you some better field for the diligence with which this work has been done.

Senator STENNIS. I would like the advice of the committee on it. I don't see where we need to go into it in detail. If you tell us it is an essential program and an austerity program, that is an assurance that we do need.

Dr. GLENNAN. There are two points I would like to make, Mr. Chairman. One is with respect to the importance of getting on with the Goddard Space Center which we started with moneys provided last year, located at Beltsville, Md. Construction is underway there and we have asked for $14 million to get underway with this. This will be the housing for our space-flight-development people.

The other is an item which was deleted from the House bill and in which we strongly urge be supported by this committee. This is an item that you will find on page 395 for propulsion-development facilities, and on page 397. This is a central facility for high-energy solid and liquid fuel rocket propellants. The reason the House deleted this is that we are not able yet to settle for a site on it. We went into substantial detail in building up the estimated costs on this particular facility. We did this with the help of some studies that had been made of a particular site.

These are simply ball-park estimates of the detail. We are going to have, in this particular facility, toxic propellants that can't be located in a center of population. We need certain supplies of water and power. We urgently need to get on with this particular job and I hope this committee, if you have questions on that particular $4,750,000, there are people who can answer them but I do hope you will put it back in this bill.

Senator STENNIS. If it is put back, it will be in dispute in conference and we really think we ought to have some testimony on it.

Dr. GLENNAN. All right.

Senator STENNIS. For that reason as well as additional reasons. I don't know that we have time to take it right at this moment.

Dr. GLENNAN. Mr. Wyatt can speak to this.

Senator MARTIN. Was this stricken in the House from the authorization bill?

Dr. GLENNAN. It was stricken, but provision was made so that we could go ahead with it if we found the right site; but in going ahead with it, we would have to reduce our total budget by $5 million to do it unless we went back for another authorization on it.

Senator STENNIS. Go ahead and cover it now.

Mr. WYATT. Sir, we have a problem here in that the more advanced fuels that we are interested in using for their high-energy content and the efficiency are unfortunately very toxic. If the fuels spew around the atmosphere, it will kill vegetation, animals, and humans. Yet these fuels do offer us a tremendous payoff in terms of the thrust advantage, the efficiency advantage and we can get it from them. We are interested in them.

Now in order to ever realize the use of these types of fuel, it is going to be necessary to conduct extensive research and development on rather large size engines of the sort that we would like to employ, and consequently we need a facility at a site which is remote enough from the general population to permit us to test these fuels with the attendant hazards and possible explosions as well as simply spewing out the exhaust products each time we fire the rocket.

Dr. Glennan has indicated we have a study team at the present time who are studying the precise requirements, the physical requirements in terms of proximity distances; how far apart do we have to put these facilities, and what type of excluding radius we have to have around the whole facility so we do not endanger people and property living in the area. We are studying this problem.

Our next problem is to select a site that is suitably remote and yet which is accessible to the people who will have to use this facility. So we need a combination of circumstances; the combination of remoteness and yet it can't be in the complete wild because we have to bring in trained engineers, technicians, and scientists.

Senator STENNIS. You say the House authorization provided you absorb it out of your other authorization figures; is that right?

Dr. GLENNAN. Yes.

Dr. DRYDEN. By this supplement, what has been said, you might get the wrong impression that isolation is the only necessity. There are also substantial amounts of electrical power, light, and water in this operation and we feel this is a matter we must consider very carefully. We really feel we ought to be commended for not rushing into this too rapidly.

Senator STENNIS. It has to do primarily with the solid-fuel problem?

Mr. WYATT. With the toxic fuels, some of which are solid, most of which are the high-energy liquid fuels.

Senator STENNIS. How could this appear at this late date as a special problem with the liquid fuels?

Mr. WYATT. These are liquid fuels that have only been handled in small quantities in small-test engines. We want to test them in development and application.

Dr. GLENNAN. We actually have at Sandusky, Ohio, test cells for very small engines of this size. This is a scaling up, up into real development work.

Senator STENNIS. It seems the House approved the idea of recognizing the need to ask you to absorb it.

Dr. GLENNAN. They held it was because of a lack of a site for it. They recognized the need for a facility, but they said we don't want to hold you up. If you think you need to go ahead with it, go ahead, but in doing this they have, in effect, decreased our funds by $4,750,000.

Senator CANNON. You haven't selected any contractors to do your experimental work?

Dr. GLENNAN. No; we are perfectly happy to come back and tell you where the site will be and all of that.

Mr. WYATT. This will be an inhouse operation.

Senator STENNIS. Do you think you will have to have this before we are back here in January?

Dr. GLENNAN. Yes, sir, and when you say back in January, Senator Stennis, it was suggested to us last year that when the bill was cut, the appropriation was cut by $45 million, we would come back in January and we have been back and it is now May 21 and we don't have a dime and we are in trouble.

Senator STENNIS. We will look into this. Is there anything further on this, Senator Martin?

Senator MARTIN. Do you consider this point on page 397 as extremely urgent?

Dr. GLENNAN. Yes, Senator Martin. We think we must get ahead with these high-energy propellants. We propose, if possible, to put this on a piece of Government-owned land, you see. And to wait another year is simply to delay the program. It is not such a large amount of money in consideration of the total budget, it seems to me.

Senator STENNIS. I don't know. It may be some fear that this is going to be put in someone's front yard.

Dr. GLENNAN. We are perfectly happy to come back and tell you about the site.

Senator STENNIS. Yes; I think we better get into it a little further. They doubtless gave it full consideration and reached a conclusion. If you could give us your plans on this and just what the problem is, it would be helpful.

Dr. GLENNAN. Right.

Senator STENNIS. And how we can alleviate it.

All right; unless there is objection, the committee will now take a recess until 2:30, and due to prior commitments that I have made that are very firm, I can't be here at 2:30. Let me say, however, that it is certainly not due to any lack of interest in this program. I will be here as soon after 3 o'clock as I can. I will ask Senator Young to preside until then.

(Whereupon, at 12:40 p.m., the subcommittee recessed.)

AFTERNOON SESSION

Senator YOUNG (presiding). Will the subcommittee come to order? Now, Dr. Glennan, will you proceed?

Dr. GLENNAN. Yes, Senator Young. I would like, if I may, to return to the construction-and-equipment section of our budget, and particularly to this propulsion facility that we have spoken about. I would like the privilege of putting into the record at a later time a document in support of this, but I would like to speak to it for just a moment.

Senator YOUNG. That request is granted.

Dr. GLENNAN. Thank you.

We now have, meeting yesterday and today, a site selection committee. They are here in Washington at the present time developing the criteria against which a site will be selected. It is my estimate that we can move ahead perhaps within 3 months' time to select such a site.

I would like to point out again the fact that this facility is a research and development facility, that we will be working with highly toxic materials, both liquid and solid. There are requirements in such a facility for an adequate supply, yet to be determined what the number would be, and for adequate power.

We would like to if possible find a facility which is sufficiently remote so that no large population centers or even very small population centers are within say 10 or 15 miles of such a site.

We do need, however, a site which is accessible in the sense that we must transport to it propellants and hardware. I think I have pointed out that we hope to find a governmentally owned piece of land which will serve for this purpose.

I point out further, as I think Mr. Wyatt stated this morning, that we have been operating in this field for several years, particularly at the Lewis Laboratory in Cleveland, and within the past year have started construction of some test cells for fluorine work at Sandusky where we have a remote site on an old ordnance site there as you know.

This is the next step in getting into advanced work in larger hardware. If we are delayed another year in this activity, I think it is reasonable to state that our program is delayed in this respect at least, in getting at the development of much more high energy propellants than any that we are presently working with by that amount of time. Now if I may then I will place this in the record at a later time.

Senator YOUNG. Doctor, is there any reason that you should be delayed in time? Can you foresee that that is likely to happen?

Dr. GLENNAN. I do not think there is a reason that we should be delayed in this. I am sure, Senator Young, that this would not be the first authorization that had been made for a site not yet selected. The amount of money involved in this at present is not very large, although our guess is that this site might grow in time to an investment of $20 million, some such thing as this, as one gets into other exotic fuel areas.

Senator YOUNG. Thank you. That answers my question.

(The statement subsequently provided by NASA is as follows:)

NATIONAL SPACE PROPULSION FACILITY

The NASA has completed a comprehensive study of the facilities required to implement a national space propulsion program. In order to expedite the Nation's space program, it is necessary that certain new construction for the research and development needed be undertaken immediately. The NASA study of these new propulsion facilities reveal the facilities required in fiscal year 1960 to be as follows:

(*a*) Liquid propellant research installation,

(*b*) Solid propellant research facility, and

(*c*) Supporting services such as propellant process, transport and storage facilities; shops; general data handling and data reduction equipment; and an operations and administrative center.

These facilities are essential in order to achieve the benefits of high-energy propellants. To date, experimental research has shown that high-energy propellants can increase the payload capacity of a space vehicle two to three times that available with propellants now in use or under development.

PROPULSION FACILITY REQUIREMENTS

1. *Remoteness of site.*—The toxicity of the high-energy fuels and the research and engineering effort necessary to the development of the fuels requires a site remote from populated areas since extremely hazardous conditions will be existing.

2. *Size of site.*—The explosion hazards as well as the toxicity of the high-energy propellants dictates a large exclusion radius between individual test components as well as between each component and any external residential area. In addition, the noise nuisance of the high thrust rockets that will be tested require the facility to be at a considerable distance from residential areas. The area requirements will vary depending on the topography, prevailing wind, and weather conditions as follows:

(*a*) On relatively flat ground approximately 60 square miles will be required for the liquid propellant facility and 20 square miles in addition required for the solid propellant facility.

(*b*) Rugged mountainous terrain and favorable prevailing winds will reduce the liquid propellant facility requirement to 25 square miles and the solid propellant requirement to 8 square miles.

(c) A water coastline site will reduce area requirements if the prevailing wind is offshore. In this case the liquid propellant facility land requirement will be reduced to 30 square miles and the solid propellant land requirement to 10 square miles.

3. *Climate.*—In order to expedite the Nation's space program, the supporting propulsion facilities must be operated on an urgent basis. This calls for a climate suitable for year-round outdoor activity to meet working conditions requiring open test stands and work areas. The site must have an average daily minimum degree temperature above 32° F. throughout the year.

4. *Power.*—An abundant supply of power is needed for the testing operations involved in the new facility. At least 10,000 kilovolt-amperes will be required.

5. *Water.*—For cooling of testing apparatus and use in power equipment, an available supply of water needs to be assured. Two million gallons per day is required, of which 250,000 gallons must be treated or domestic water.

6. *Industrial support and labor supply.*—A nearby supply of a wide variety of technical skills and industrial machine and fabricating shops will be required for the efficient and economical operation of the facility.

7. *Cultural environment.*—It is desirable that the site be in close proximity to a culturally attractive community and to educational institutions in order to attract and retain a competent staff.

8. *Transportation and communication.*—Adequate transportation and communication must be available, or readily installed, to support the operation of the facility.

9. *Site development costs.*—Consideration must be given to the cost of developing each site to the level required for the planned facility.

FUNDS REQUESTED FOR PROPULSION FACILITY

In fiscal year 1960, the NASA has requested $4,750,000 to start construction on the new propulsion facility. In the justifications submitted to the Congress, questions have been raised concerning the amounts submitted for water, electrical power, roads and fencing, and site preparations. The concern has been expressed that inasmuch as NASA has not selected a site for this new facility the figures submitted for the above-mentioned items would vary depending upon the particular site finally selected. In arriving at the estimates for these items the NASA has taken advantage of studies made by its own personnel and the military departments in establishing facilities or laboratories in remote areas. The specific requirements relating to the remoteness of the site and the climate indicate that the estimates for these items are reasonably accurate and will not vary substantially in either direction once the site has been selected.

A site selection committee is currently reviewing the areas in the country which meet the above requirements, and it is expected that a selection will be made in the near future. In order to reduce the costs to a minimum, only available Government-owned land is being considered. The House of Representatives, in taking action on H.R. 7007, deleted this item from the legislation but made it possible for NASA to take action on the facility once a site was selected. However, the effect of this action was to reduce NASA's construction authorization by $4,750,000. This reduction will place equally critical facilities behind schedule by at least a year.

Dr. GLENNAN. Then, Senator Young, if we may go to the section of our budget on salaries and expenses, and in this connection—there was one other point I believe.

May I reverse my field. Mr. Lehrer spoke to me during the lunch period about an equatorial launch site and our interest in one. I am sure that if there were an equatorial launch site we would have a real interest in it, and I am sure that if there is one developed in the period of the next few years, we will be involved in it in a closely coordinated fashion.

Mr. Lehrer pointed out several articles that had appeared in the press. I think these are articles which are not founded on very much fact and are probably simply fishing for confirmation or denial. I will from the NASA standpoint say frankly that we are more interested

in trying to determine whether or not it is necessary to have an equatorial launch site than in going ahead to build one.

With the ability to propel larger and larger payloads into orbit, the ability to steer those into an equatorial orbit once launched from any other site seems to us at present to be perhaps a more rational and less expensive approach in this. So for the record let it be said that we are certainly interested in determining what the economics are and what the real need for such a site is. But in our budget request for fiscal 1960, we do not include any request for moneys for an equatorial launch site. Did you have any questions on that?

Senator YOUNG. Have you any questions in that connection?

Mr. LEHRER. Yes, sir, I have a few questions that deal with construction.

Dr. Glennan, the budget justification calls for some $250,000 for the in-pile loop and $605,000 for the zero-power reactor at the Lewis Research Center. Could you tell us exactly what the relationship is between those projects and the work of the Atomic Energy Commission?

In other words, why is that work being done by NASA rather than by AEC?

Dr. GLENNAN. May I ask Mr. Abbott to speak to that?

Mr. ABBOTT. Speaking to the more general question first, as to why this is not being done by the AEC, we have had a cooperative program for many years now between the NACA and the AEC in this general field of nuclear power.

The AEC has the primary cognizance there in the aspects which relate primarily to the reactor. There are many supplementary aspects to this thing, however, which include the whole complex of machinery which is associated with the reactor to get the power either for conventional nuclear-powered airplanes or for nuclear rockets. These fall by agreement in our province as far as research and development is concerned.

There are also certain research problems on such matters as materials, heat transfer, and this sort of thing which have applications within the reactor—the reactor construction itself—in which we are carrying part of the total research load in cooperation, and of course coordinated, with the AEC.

Now with regard to these two matters that you mentioned, as you know, we do have this reactor at Plumbrook Ordnance located near Sandusky, Ohio, which is now nearing completion and will be going into operation very soon.

The zero-power reactor is in many respects a duplicate of a large part of the power reactor, but one which is made not to furnish power but to come up to the critical point.

This is in essence a device to improve the safety of the overall operation and also to permit us to determine what problems we may run into in conducting experiments in the reactor itself.

We won't go so far as to say that this zero-power reactor is a must from the point of view of safety for the operation of the reactor. But without it we will be greatly handicapped in the type of experiments that we would be willing to undertake without creating hazards.

This zero-power reactor has been recommended by the safety committee of the Atomic Energy Commission. The in-pile loop is simply

an experiment to be run in the reactor. The only reason it appears in this construction and equipment program which is before you is because the price of these items is rather high.

This one you see is $250,000, which is the limit of our authorization for constructing a single piece of equipment. Hence it appears in this program. It is, however, a single experiment to be run in the reactor, and contains the elements that are necessary to study the other parts of the system of a nuclear powerplant, including a single fuel element which was inserted in the reactor itself to provide the basis for the experiment.

Dr. DRYDEN. May I just add one remark. The history of this, of course, goes back a good many years. When the decision was made jointly by the old NACA, AEC, and the Defense Department to have the NACA obtain a reactor as a research tool, there were letters in the record to the Congress recommending this from AEC and from the Department of Defense.

The reactor that we have is a research tool. It is not a prototype of a reactor to go into an airplane. It is akin to the materials test reactor of the AEC. We have the function, as has been mentioned, of dealing with research on the nonnuclear aspects of nuclear propulsion. The various equipment that is used is in the radiation field, and so we have to investigate the radiation environment as well as the ordinary material properties.

The zero power reactor is a research tool to make the operation of the big one safe because in the big one we are putting specimens and when you put a specimen in the reactor it changes the operating conditions slightly. We will try this out in the zero-power reactor to make sure that we are not promoting some unsafe condition in the large reactor.

Mr. LEHRER. There is also a request for $2 million for facilities for the Rover program.

Dr. DRYDEN. Yes. This is being carried out through the AEC. That means a facility which we are financing but will actually be built by the AEC in support of the Rover program for nonnuclear aspects.

Mr. LEHRER. This will be worked on as an integral part of the AEC program?

Dr. DRYDEN. That is correct.

Mr. LEHRER. And the AEC is financing the nuclear aspects itself?

Dr. DRYDEN. That is correct.

Mr. WYATT. May I add just a little bit to that?

The AEC in the nuclear rocket field is doing the reactor work. In this particular case we are going to support the pumps and equipment required to put the propellant through the reactor and this equipment here is to furnish the test equipment to put the pumps at the reactor site so that we can actually drive a working fluid through the reactor.

Mr. LEHRER. So that we could have a complete story on Project Rover and the relationship of AEC costs and Department of Defense costs to those being borne by NASA——

Dr. DRYDEN. There are no Department of Defense costs. The nonnuclear support was transferred from the Department of Defense to NASA at the time NASA was established. These costs were previously in the Air Force budget.

They now appear in the NASA budget.

Mr. LEHRER. Will you provide for the record a table that would incorporate both AEC and NASA costs and an explanation of the criteria used to divide funding responsibility between the agencies?

Dr. GLENNAN. Yes, sir.

(The information subsequently provided by NASA is as follows:)

NASA relies upon the Atomic Energy Commission for research and development work on nuclear reactors. In the cooperative jobs on which NASA is working with the AEC, the NASA will be responsible for incorporation of the reactor into the system and for research and development on components other than the nuclear reactor. The present AEC and NASA budgets incorporate the following division of responsibility:

(*a*) AEC budget on reactor feasibility research for the Rover project:

	Million
AEC operation:	
Fiscal year 1959	$14.0
Fiscal year 1960	15.0
AEC construction:	
Fiscal year 1959	12.5
Fiscal year 1960	4.8

(*b*) NASA budget on nuclear engine work which includes the NASA Rover project:

	Million
NASA:	
Nuclear engines, fiscal year 1959	$4.5
Nonnuclear components and system development, fiscal year 1950	8.0
Facilities, fiscal year 1960	2.0

Mr. LEHRER. Your justification also indicates $1,355,000 for a data acquisition station on Bermuda which it is indicated will include reception of telemetering data from rocket and satellite vehicles launched from Wallops Island and Cape Canaveral. Please explain the function of this station.

Dr. DRYDEN. This station is primarily a station for Project Mercury to determine whether the capsule goes into orbit or whether we should terminate the flight. In other words, we have to measure very quickly what the speed and altitude of the capsule is. If it comes out from the computations that the capsule is not safely in orbit, then we must terminate it and bring it down in the Atlantic where we can rescue it, instead of letting it go on and land perhaps in Africa or the Indian Ocean or someplace. This is the primary purpose of the station. Project Mercury, of course, as you saw, was fired to the northeast from Canaveral over Bermuda, and because of the geometry so that it would come back and land in the Cape Canaveral area.

In addition to that primary function, this station will be used in connection with satellite firings from Wallops which are a very small proportion of the total number of firings from Wallops Island, again to serve the purpose of seeing whether it has gone into orbit. This station will be operated by NASA personnel. In the Mercury operations it functions as a part of the Atlantic Missile Range. In other words, during that operation it reports directly into Canaveral.

RELATIONSHIP BETWEEN WALLOPS ISLAND AND CAPE CANAVERAL

Mr. LEHRER. Dr. Glennan, I wonder if you would cover for the committee the exact relationship between the work being done at Wallops Island and at Cape Canaveral, since there seems to be an impression created that there is duplication between the two.

Dr. GLENNAN. I will be glad to. In the first place, let me point out that Wallops Island has been a station, an operating rocket launching station of the NACA and more recently of the NASA for 14 years. It is not a Johnny-come-lately which has been built up in competition with or to duplicate the work of Cape Canaveral. This station will be manned by not more than 300, probably around 250 people.

Its responsibility will be essentially limited to the use of solid propellent rockets. It will be used for some few satellite launchings, using the Scout vehicle. It is an unclassified station where we can take foreign visitors as we develop cooperative programs with our friends across the ocean.

At Cape Canaveral where you have 18,000 personnel involved, you have very large, very expensive, and very complex facilities necessary to the launching of liquid fuel rockets of high thrust and to many others of the military type of rockets and guided missiles. There is really no duplication in this, Mr. Lehrer. To take one of our small rockets, even a Scout at Cape Canaveral, and this could be done, would be a rather expensive venture.

So far as the possibility of the operation of Wallops Island station interfering with the air traffic or becoming a nuisance there, you should know that there is essentially no countdown in a solid rocket of the types that we will use there. We have entered into agreement with the CAA so that the control of our firings is done in New York by the CAA controller. There is no possibility that we can see of any interference with air traffic in that area.

Mr. LEHRER. Are these agreements in writing, Dr. Glennan?

Dr. DRYDEN. Yes.

Mr. LEHRER. Could you provide them for the record?

Dr. GLENNAN. We will be glad to. Further, I do have here a memorandum which is of recent date, May 1, which sets forth the functions of the Wallops station and the organization and I would be glad to supply this for the record if you wish.

Senator YOUNG. Yes; that will be made a part of the record.

(The documents referred to follow:)

RELATIONSHIP BETWEEN WALLOPS ISLAND AND CAPE CANAVERAL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 1, 1959.

Memorandum from the Administrator.
Subject: Functions and authority, Wallops Station.

1. Purpose of this memorandum:
   (*a*) To transfer the Wallops Station to the jurisdiction of the Office of Space Flight Development, NASA Headquarters.
   (*b*) To provide a statement of functions and authority for Wallops Station.
2. Functions: The Wallops Station is assigned the following functions:
   (*a*) Making all necessary arrangements for and conducting tests of rocket-propelled test vehicles as requested by other NASA facilities or headquarters;
   (*b*) Developing supporting or specialized instrumentation necessary in the conduct of tests;

(*c*) Developing and constructing necessary launching facilities to be used in the conduct of rocket tests;

(*d*) Developing and providing necessary tracking and data-acquisition facilities for use in the conduct of tests;

(*e*) Supervising recovery operations as necessary to recover vehicles tested at Wallops Station;

(*f*) Performing necessary development work in order to make minor modifications in vehicles under test at Wallops Station;

(*g*) Making special arrangements for use of test facilities by other groups;

(*h*) Performing tracking as directed by NASA Headquarters on vehicles launched at other test facilities;

(*i*) Exercising such procurement and contract administration authority as may be delegated by the Director, Office of Business Administration; and

(*j*) Providing necessary administrative and management support as required for carrying out assigned programs.

3. Responsibility of the Chief, Wallops Station: The Chief, Wallops Station, reports directly to the Director of Space Flight Development and is responsible for the exercise of the functions assigned to the Wallops Station.

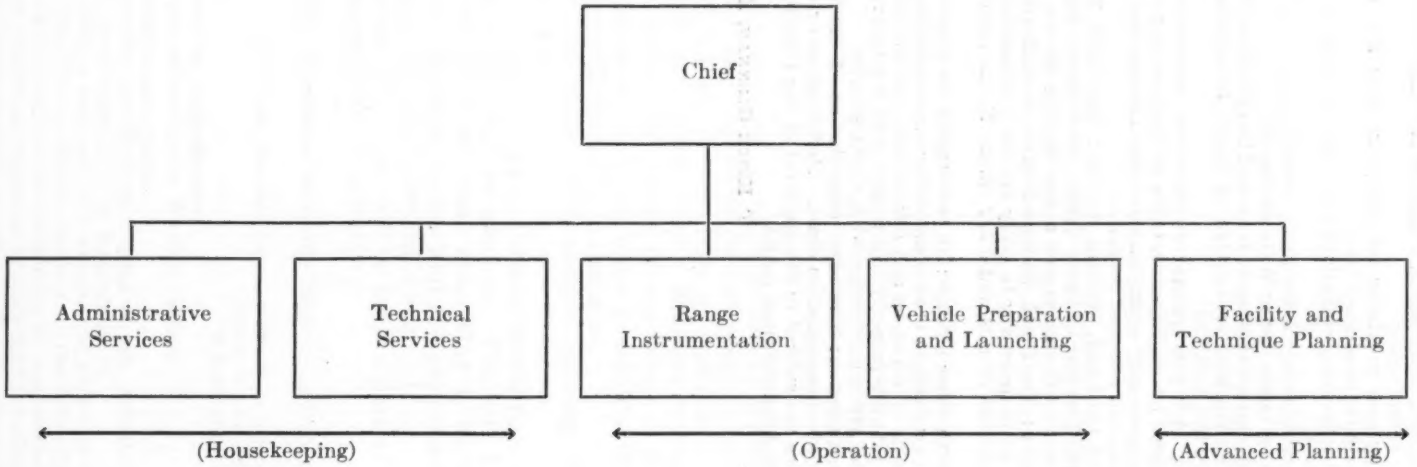
4. Scope of authority: The Chief, Wallops Station, is authorized and directed to take such action as is necessary to carry out the responsibilities assigned to him within the limitations of this and other official NASA communications and issuances.

5. Relationships with other officials: In performing the functions assigned to him, the Chief, Wallops Station, is responsible for recognizing the responsibility and authority of heads of divisions and offices, headquarters, and for assuring that actions he may take are properly coordinated with headquarters groups having joint interests and are in accordance with NASA policies.

6. Approval of organization: The basic organization of the Wallops Station is outlined on the attached organization chart. Modifications or changes in basic organization structure are subject to the approval of the Director, Space Flight Development, and the Administrator, NASA.

T. KEITH GLENNAN, *Administrator.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WALLOPS STATION
ORGANIZATION CHART



Approved: T. KEITH GLENNAN,
Administrator, NASA.

Date: MAY 1, 1959.

NEW YORK AIR ROUTE TRAFFIC CONTROL CENTER AND WALLOPS STATION OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LETTER OF AGREEMENT

Subject: Rocket and missile test operations.
Effective: March 1, 1959.

PURPOSE

To establish a working agreement and delineation of operating responsibilities between the National Aeronautics and Space Administration (NASA) Wallops Station and the Federal Aviation Agency New York Air Route Traffic Control Center for the purpose of assuring safety for nonparticipating aircraft during those periods in which rocket and missile operations are scheduled to be conducted from Wallops Island, Va., to various points within or through the New York oceanic control area.

NASA will conduct its rocket firing operation in accordance with the controlled firing concept. To accomplish this, NASA, by means of its surveillance capability in conjunction with information received from the New York center, will determine traffic in or adjacent to the firing area and shall thereafter conduct firing so as to assure safety for nonparticipating aircraft.

OPERATING PROCEDURES

A. NASA responsibilities

The NASA Wallops Station will:

1. Notify the New York center by telephone, confirmed by telegram at least 10 days in advance of each individual scheduled launching, when the rocket operating area is within the New York oceanic control area. This notification shall include:

(*a*) time and date.

(*b*) description of the rocket operating area including location of impact operating area(s) defined by latitude, longitude, and MSL altitudes. The size of the area(s) must be such as to assure at least a 95-percent probability factor of containing the rocket.

(*c*) estimated total flight time in minutes.

2. The NASA Wallop's range safety officer will not permit launchings to be made when nonparticipating aircraft are (1) within the rocket operating area; (2) within the buffer zone defined as the area lying within 60 nautical miles laterally of the impact operating area(s), or 50,000 feet vertically of the rocket operating area or the buffer zone while the rocket is in flight.

3. Prior to authorizing a rocket or missile firing, inform the New York center by telephone during countdown at—

(*a*) T–6 hours;

(*b*) T–90 minutes;

(*c*) T–60 minutes;

(*d*) T–20 minutes (direct communications between the New York center and Wallops' range safety officer established);

(*e*) when, after T–90 minutes, any count is being held for more than 5 minutes and the estimated duration of the hold.

4. In case of telephone communication breakdown between the range safety officer and the New York center before launching, the range safety officer will discontinue count until such time as communications are reestablished.

5. Give the New York center the following:

(*a*) actual time of launching;

(*b*) operation termination notification—"Operations Complete."

6. Immediately advise the New York center when scheduled launchings are canceled or postponed. The rescheduling will be at a time mutually agreeable to both parties.

7. The NASA Wallops' range safety officer, in addition to obtaining data on known flights, will be responsible for providing, to the extent practicable, radar surveillance and/or visual surveillance in the—

(*a*) launching area;

(*b*) the booster stage impact areas; and

(*c*) the final stage impact area.

B. New York center responsibility

The New York center will forward to NASA Wallops Station the following data:

1. Flight plans on aircraft estimating to be within or to penetrate the rocket area during the period of time from 60 minutes prior to scheduled launching time, to and including the estimated duration of the rocket flight, and until 30 minutes after the rocket firing is estimated to be completed.
2. All flight plans on aircraft estimated to pass within 60 nautical miles laterally or 50,000 feet vertically of the rocket operating area during the period of rocket operation.
3. At the request of the range safety officer, this type of flight data will be supplied for additional areas adjacent to the rocket operating area as specified.
4. The last current position reports of the aircraft in paragraphs 1, 2, and 3 above, until such time as the rocket operations are completed.
5. Should the range safety officer advise that due to conditions beyond his control he is unable to withhold or control a rocket firing, the New York center will, to the best of its ability, reclear aircraft out of or away from the rocket operating area. This shall be considered as an emergency situation.

GENERAL

1. In the event that NASA firings have special requirements not covered in this agreement, individual coordination will be effected between the participating facilities.
2. It is understood that the NASA Wallops Station is the coordinating agency for all launching operations originating at Wallops Island.
3. NASA will keep FAA informed of the equipment and procedures used to assure surveillance of rocket operating areas.
4. NASA will provide, insofar as possible, a proposed launching schedule to New York center for each calendar year.

ROBERT L. KRIEGER,
Chief of Wallops Station.
LEIGH V. REYNOLDS,
Chief Controller, New York Center.

Mr. LEHRER. It is noted that no construction funds are requested in 1960 for Wallops Island.

Dr. GLENNAN. That's right.

Mr. LEHRER. Does this indicate that you have substantially completed the buildup program at Wallops Island and Chincoteague?

Dr. GLENNAN. For the present this would appear to be the case, yes. We have no long-range plans for greatly enlarging that.

Dr. DRYDEN. It might be well to point out that, as originally financed, there were some buildings to be built on the mainland opposite Wallops Island. Then the Chincoteague Naval Station was declared surplus, and it did not seem right to anyone to start new Federal construction 4 miles away from very ample modern facilities. At Chincoteague there are, I would say, in the way of buildings, buildings way beyond anything we can foresee for the use of NASA.

In later budgets there may be additional instrumentation at Wallops Island. With the funding already provided, the so-called expansion consisted of building a causeway so that we did not lose 20 minutes at the beginning and end of every day by ferrying everybody across to the island and providing additional radar equipment in taking all the housekeeping personnel off the island, putting telemetering at Chincoteague and control centers. So the expansion was really not so much an expansion as making the place more efficient in its operation, more adequately provided with instrumentation. I guess that is about the story.

Mr. LEHRER. One final question on construction, Dr. Glennan. In our previous hearings you had indicated, or I believe Dr. Dryden indicated, that NASA was letting contracts directly rather than operating through the Corps of Engineers or the Bureau of Yards and Docks. Could you tell us what procedures you use in terms of competitve bidding versus negotiation?

Do you have policies comparable to those of the Corps of Engineers and Bureau of Yards and Docks?

Dr. GLENNAN. Can I ask our business manager, Mr. Siepert, to speak on that?

Mr. SIEPERT. We are operating in this area in the same fashion as the NACA has operated for many years. Because our facilities are quite highly specialized, we have built up over the years in our own laboratories people who are very skillful in the design of unique functional facilities.

We have now, as in the past, been awarding these contracts by an active program of competition, and in this direct competition we seek in practically all cases to get this on a fixed-price basis. So this is a straight low-bidder arrangement. Customarily our bid list includes some 12 to 15 competent construction companies. We handle all of our construction in this fashion. We believe we are able to get what the Government needs at the cheapest possible price when we handle it directly.

Mr. LEHRER. That is all, Mr. Chairman.

Senator YOUNG. Will you proceed, Doctor?

Dr. GLENNAN. I would like then, Senator, to turn to the salaries and expenses for fiscal year 1960 and ask Mr. Siepert if he will speak to the $94,430,000 request which would cover the addition to our staff, about 1,027 people at 4 locations, and the services that will support them.

We will refer to pages 5 and 7 in our justification book.

(The pages referred to follow:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Salaries and expenses, fiscal years 1959 and 1960

	Number of employees			1959 allotments	1960 estimates
	1959	1960	Change		
NASA Headquarters	336	486	+150	$4,864,850	$6,402,000
Langley Research Center	3,333	3,333	.....	30,683,000	32,724,000
Ames Research Center	1,509	1,509	.....	16,487,150	18,352,000
Lewis Research Center	2,828	2,828	.....	27,606,000	31,733,000
High-Speed Flight Station	322	322	.....	2,833,100	3,354,000
Space Projects Center	527	1,247	+720	2,639,600	14,744,750
Pilotless Aircraft Station	97	250	+153	1,241,920	3,626,000
Patrick Office	3	3	.....	27,400	55,250
Western Coordination Office	4	8	+4	49,605	80,000
Wright-Patterson Liaison Office	2	2	.....	21,375	22,000
Total	8,961	9,988	+1,027	86,454,000	111,100,000
Funded under "Research and development"	.....	.....	.....	.....	−16,670,000
Total appropriation	.....	.....	.....	[1] 86,454,000	94,430,000

[1] Includes anticipated supplemental (Classified Pay Act increase) in the amount of $3,354,000.

Estimates of appropriations, salaries and expenses, fiscal year 1960

	Fiscal year 1958, obligated	Fiscal year 1959, estimated	Fiscal year 1960, estimated
01 Personal services:			
Number of permanent positions (end of year)	7,892	8,961	9,988
Annual cost of permanent positions (end of year)	$54,165,461	$63,178,541	$71,599,991
Deduct lapses	3,307,597	4,877,046	2,749,856
Net cost of permanent positions	50,857,864	58,301,495	68,850,135
Intermittent employment	925	20,000	105,000
Regular pay above 52-week base	206,102	242,235	550,715
Overtime and nightwork differential	305,627	386,570	441,050
Uniform allowances	5,855	8,600	10,600
Reimbursable details		18,000	18,500
Total, personal services	51,376,373	58,976,900	69,976,000
02 Travel	402,178	1,212,500	3,181,000
03 Transportation of things	201,973	279,000	349,000
04 Communications services	224,348	438,450	3,827,000
05 Rents and utility services:			
Electric power	6,349,831	7,052,900	7,669,000
Other utilities	270,719	382,300	447,000
Rentals	1,009,796	1,707,100	3,765,000
06 Printing and reproduction	119,476	139,140	210,500
07 Other contractual services:			
Educational and scientific institutions	410,000	850,000	(1)
Other Government agencies	205,284	285,330	[1] 114,000
Non-Government facilities	531,179	596,900	[1] 935,000
Repairs, alterations, and minor construction	1,119,757	1,055,270	[1] 1,728,000
Security investigations	118,015	180,000	350,000
Federal life insurance	158,050	188,863	213,560
08 Supplies and materials	7,120,273	6,099,652	[1] 8,283,000
09 Equipment	3,275,013	3,250,150	[1] 5,610,000
11 Grants, subsidies, and contributions	3,141,148	3,740,275	4,420,540
13 Refunds, awards, and indemnities	2,079	5,000	6,000
15 Taxes and assessments	10,121	14,270	15,400
Total	76,045,613	86,454,000	111,100,000
Funded under "Research and development"			[1] −16,670,000
Unobligated balance	30,596		
Anticipated supplemental (Classified Pay Act increase)		−3,354,000	
Total allotment	76,076,209	83,100,000	94,430,000

[1] Funded under "Research and development."

Mr. SIEPERT. Page 5 is an itemization of our personnel where it is located and the changes from the present year to those requested for 1960.

Page 7 is a breakdown of the costs in this appropriation by "Other object" classification.

I might call your attention to the fund transfer mentioned earlier on the "Research and development" appropriation; there is a deduct item on page 5 which you will see at the bottom with the caption "Funded under 'Research and development', $16,670,000."

This deduction shown here has been justified as a part of the "Research and development" appropriation. It represents the transfer out of this account of items which support our inhouse research laboratories, items which are not usually paid for on a periodic or annual appropriation basis. We have kept in the salaries-and-expense account those items which are repetitive in nature such as our utility bills, travel, rentals, communication costs, and the like, since these bills become due just like the payroll.

This leaves us with a net of $94,430,000 to run the various NASA field locations and headquarters as shown here on page 5. I call your attention to the fact that the largest elements in our program are the ones referred to as the Langley Research Center, and the Ames Re-

search Center, and the Lewis Research Center; Langley in Virginia; Ames near Palo Alto, Calif.; and the Lewis Research Laboratory just outside of Cleveland.

These three stations plus a smaller one called the High-Speed Flight Station, which is located at Edwards, Calif., represent the core of the research facilities which were built up under the NACA and were taken over with the organization of NASA. With respect to these facilities, we are asking for the next year no increase in personnel. This, not to say that we are not asking for more funds for them, because in terms of the support of these facilities, their materiel and equipment costs, these have been increasing, both in volume, in unit cost, and in the complexity of the instrumentation that they need to do their job.

But the level of personnel in this area has been kept at its present 1959 level. You will notice on page 5 that the increases in personnel are concentrated in three new areas. One is the NASA headquarters. The second is the Goddard Space Project or Space Flight Center, and lastly the Wallops Station which is shown here as the pilotless-aircraft station.

These three areas of increase represent programs directly related to our new mission in the field of space research.

Mr. LEHRER. Mr. Siepert, the figures that you have quoted represent estimated employment at the end of fiscal year 1959 compared with 1960. Could you tell us how your actual employment as of the present time compares with the estimates that the justification books show for June?

Mr. SIEPERT. Yes, sir. Let me give you that as a summary figure. 1959 shows 8,961 jobs. Our actual employment as of May 15 is 8,706 jobs.

Mr. LEHRER. Since the totals are that close, I think we can save time if you will provide the details for the record.

Mr. SIEPERT. I will provide the comparable ones against each of these sites; yes, sir.

(The information is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Salaries and expenses, fiscal years 1959 and 1960

	Number of employees				1959 allotment	1960 estimate
	May 15 on duty	1959	1960	Change		
NASA headquarters	397	336	486	+150	$4,864,850	$6,409,000
Langley Research Center	3,258	3,333	3,333	.....	30,683,000	32,724,000
Ames Research Center	1,441	1,509	1,509	.....	16,487,150	18,352,000
Lewis Research Center	2,779	2,828	2,828	.....	27,606,000	31,733,000
High-speed flight station	305	322	322	.....	2,833,100	3,354,000
Goddard Space Center	383	527	1,247	+720	2,639,600	14,744,750
Pilotless aircraft station	137	97	250	+153	1,241,920	3,626,000
Patrick Office	[1] 3	3	3	.....	27,400	55,250
Western Coordination Office	6	4	8	+4	49,605	80,000
Wright-Patterson Liaison Office	.....	2	2	.....	21,375	22,000
Total	8,706	8,961	9,988	+1,027	86,454,000	111,100,000
Funded under "Research and development"	.....	.....	.....	.....	.....	−16,670,000
Total appropriation	.....	.....	.....	.....	[2]86,454,000	94,430,000

[1] This figure actually included in figure of Space Projects Center on p. 13.
[2] Includes anticipated supplemental (classified pay act increase) in the amount of $3,354,000.

I might say this is a very small vacancy figure. At this date we are holding these vacancies because we have one of our best chances in years ot get bright young engineering graduates who will come on upon completing their graduation the first of June. We actually have some 400 acceptances from some 1,200 offers to engineering graduates; some of these will come on before July 1, so we will be right up to quota.

Senator YOUNG. That will be about the middle of June, will it, that you will have this available; from then on?

Mr. SIEPERT. This employment is coming on quite rapidly. This will be a close photofinish to come right up to this 8,961 jobs by June 30. May I say one thing further in explanation here?

Senator YOUNG. Yes.

Mr. SIEPERT. That the staffing shown here in 1959 represents planning that was done at a much earlier date in our programing. These figures were actually jelled last fall. We have found that with respect to the NASA headquarters staff, that we have not been able to keep the pace of planning this national program with the headquarters staffing that is shown here for 1959.

As a result, the 336 jobs shown here have actually been revised upward by our holding back employment in other areas for us to reach a target figure of 468 by June 30. Against that headquarters figure there are 397 now on board.

Senator YOUNG. Dr. Glennan, on March 31 in a letter you wrote to Roger Jones, Chairman of the U.S. Civil Service Commission, you arrive at a gloomy picture compared to the testimony we have just heard. You stated in part in that letter:

> The National Aeronautics and Space Administration is faced with a serious problem in the recruitment of qualified scientific personnel for the Nation's space and aeronautical programs. In brief the problem centers about our inability to meet staffing requirements because of low pay. In order that important programs such as Project Mercury may proceed without delay, authority is requested to raise the minimum rates of pay to the maximum scheduled rates of each grade from GS–5 through GS–17 for positions in all series identified in Departmental Circular 793, Supplement 15.

You went on to say in accompanying background information that since December 1958, your recruitment situation has steadily deteriorated. I am now quoting your words, Dr. Glennan:

> Despite intensive efforts we have been unable to attract a sufficient number of trained scientists from industry to staff key programs at the middle and higher grades because of salary deficiencies.

Now has that situation markedly changed?

Dr. GLENNAN. Yes, the situation has markedly changed and we have withdrawn that request.

Mr. SIEPERT. May I comment on that, Mr. Chairman, in one way here. Our request to the Commission was made in March when it looked doubtful that our college recruitment efforts would achieve success. We are gratified that we now have had 400 acceptances, but we need to keep in mind that the hunting season for young engineers occurs only once a year, and it occurs at June. Our figures will show that we are in the market in our request for 1960 for 1,000 more people, plus a need to replace that fraction of technical and other people who leave us each year.

So while we are pleased with the 400, we do have a tight situation in terms of assuring ourselves that we will be able to continue to attract engineers throughout the year. We think we are fortunate on this year's engineering graduates.

We know as of now that with respect to this request to the Civil Service Commission, we are still offering new college graduates a thousand dollars a year less than they will be able to get if they go into industry. We are delighted that they like our program well enough that they are willing to come with us in spite of that salary differential.

Senator YOUNG. As of now do you know about the better students that are graduating in the middle of June? As of now how are you succeeding with them?

Mr. SIEPERT. We know that industry offers on the average $6,500 for an engineering graduate from a good school. We can offer $5,430. For top students the information we are getting from industry is that they offer $7,000 or more. Now, of course, we have to offer the same salary in the Government whether they are good, medium, or mediocre. We don't offer the mediocre student a job but we are limited to the same rate of pay.

Senator YOUNG. What do you consider as the better student, the top third or the top 25 percent?

Mr. SIEPERT. NACA, our predecessor organization, for some years was able to attract the great bulk of its appointees from the top one-quarter of the graduating class. I do not have the figures with me, but that situation deteriorated from 1950 when NACA got the great bulk of them from that level, to a greatly reduced proportion of the top quarter of the students by 1957. This I think was our low year. This is improving. I can probably supply information for the record on where the standing of our applicants is at the present time.

Senator YOUNG. Then at the present time let's give consideration to the top 25 percent of the number of the graduating students this June. Are you able to give this subcommittee an idea or the committee an idea as to how you are faring with the top students?

Mr. SIEPERT. I do not have that figure, and I am not sure I could supply it immediately. I will have to check with our Personnel Office. My estimate on this would be that we are not in this respect doing as well as we were in years prior to 1954, because the competition for the top student is very keen.

Senator YOUNG. You will, by early in June, be able to have that information; will you not?

Mr. SIEPERT. I think we could; yes, sir.

(The information referred to is as follows:)

STATEMENT ON THE QUALITY OF THE 1959 BS SCIENCE GRADUATES ACCEPTING POSITIONS WITH THE NASA

Of the graduating scientists and engineers hired this year by NASA, 52 percent were in the top one-fourth of their graduating class. This compares with 70 percent in 1951 and a low of 33 percent in 1956. In 1956 and 1957 the figure rose only to 35 percent. The 52 percent is a marked improvement over the preceding 2 years, no doubt because of the appeal of the Agency's new mission and the widespread publicity NASA has received.

The NASA has been less successful in recruiting graduates with advanced degrees. NASA this year has made 161 offers to graduates with masters degrees and 43 accepted. Similarly, NASA made 42 offers to Ph. D.'s and only 5 accepted.

Senator YOUNG. Dr. Glennan stated in his letter at that time:

> A serious decline in recent years was also noted in the percentage of better students accepting NASA employment.

Do you think that situation really is changed as of now, markedly changed?

Dr. Glennan, will you be able to give this committee that information by the middle of June?

Mr. SIEPERT. We will do our best, sir. Part of the difficulty we have on this is that getting class standings and the like is related to final grades a man gets when he graduates, so we get the final information actually after he has been employed by us. Complete information on this probably would not be available until a later time in the summer.

Senator YOUNG. What are the facts, from your own observation, about the top 25 percent of the graduates? Is it frequently the case that a graduate who did not attain that high rank scholastically may in initiative and industry and other qualities turn out better?

Mr. SIEPERT. Yes; one always has to include this in one's possibilities. However, in spite of a lot of people who are working to improve methods of prediction in this area, no one has come up with a particularly better diagnostic tool than academic standing in order to then determine how one will do in research.

Senator YOUNG. Dr. Glennan, relative to the recruiting problem information to be submitted by the middle of June, will you also be able to submit to the committee all of the related information, including recent correspondence with the Civil Service Commission, on this problem?

Dr. GLENNAN. Yes.

Senator YOUNG. So we may have that for the record?

Dr. GLENNAN. Yes, sir.

(The information referred to is as follows:)

STATEMENT ON THE PRESENT STATUS OF THE NASA REQUEST FOR TOP-OF-THE GRADE PAY FOR AERONAUTICAL RESEARCH SCIENTISTS

The correspondence referred to in the above questioning covers NASA's initial request and ends with NASA's presentation of additional information submitted at the request of the Civil Service Commission. The complete file is enclosed. Subsequently, after discussions between NASA and the Civil Service Commission, the NASA request has been withdrawn for several reasons. There are substantial administrative difficulties in raising aeronautical research scientists to the top of the grade for a single agency, since similar positions exist in other agencies. The Defense Department, which has nearly all such positions outside of NASA, does not support the increase because it does not at present face hiring needs for these skills to the extent NASA does. Finally, our spring recruiting of college engineering graduates has had better than expected results. Out of 1,200 offers, we found 400 acceptances. These efforts were successful in all our large research centers except for our high-speed flight station, located in a remote site in California, where 32 offers were made with only 1 acceptance to date.

The encouraging upturn in college recruiting, however, has not been matched in the recruiting of certain types of experienced scientists and engineers in grades above the entrance levels. Specialists in such fields as space tracking and communications are in short supply.

U.S. CIVIL SERVICE COMMISSION,
BUREAU OF DEPARTMENTAL OPERATIONS,
Washington, D.C., April 9, 1959.

To: Heads of departments and independent agencies.
Subject: Request from National Aeronautics and Space Administration to increase the minimum rate of pay for aeronautical research scientists.
(Attention: Directors of personnel.)

The Civil Service Commission has been requested by the National Aeronautics and Space Administration to further increase the minimum rate of pay under section 803 of the Classification Act for positions in the 34 specializations listed in Departmental Circular 793, supplement 15, grades 5 through 17.

The request specifies that the minimum entrance rate for each grade be set at the top step. Geographic coverage: Nationwide.

The agency has submitted information to show:

(*a*) The number of vacancies now and anticipated within the next 12 months.

(*b*) The supply of eligibles available for filling positions in the 34 specializations.

(*c*) Recruiting experience for these positions.

(*d*) Salary rates paid by non-Federal employers.

The law specifies that a decision to raise the minimum rate will require all Federal agencies to increase the pay of their current employees in the specified classes of positions to the new minimum rates and to hire all new employees at the new minimum rates.

We are furnishing this information so that you may consider the effect it would have on your department (or agency) if the requested increases are granted. You should consider your own recruiting experience in regard to these positions, the number of such positions in each grade in your department or agency, and your present and anticipated needs for these positions.

On Friday, April 17, at 9:30 a.m., a meeting will be held in room 377, Civil Service Commission, main building, Eighth and F Streets NW., to consider the effect of NASA's request on all Federal departments and agencies concerned. If your department or agency employs an appreciable number of persons in these or related positions, please send a representative to this meeting authorized to present the official position of your department or agency.

If you care to present your official position in writing, please address it to the Commission, attention Examining Division, room 207–P, and submit it either at or prior to the meeting.

Sincerely,

DONALD R. HARVEY,
Chief, Examining Division.

Hon. ROGER JONES,
Chairman, U.S. Civil Service Commission,
Washington, D.C.

DEAR MR. JONES: The National Aeronautics and Space Administration is faced with a serious problem in the recruitment of qualified scientific personnel for the Nation's space and aeronautical programs. In brief, the problem centers about our inability to meet staffing requirements because of low pay. In order that important programs such as Project Mercury may proceed without delay, authority is requested to raise the minimum rates of pay to the maximum scheduled rates of each grade from GS–5 through GS–17 for positions in all series identified in Departmental Circular 793, supplement 15.

Supporting information pertient to this request is contained in the enclosure to this letter.

Because of the urgency of the present situation immediate approval of this rate increase is respectfully requested.

Very truly yours,

T. KEITH GLENNAN, *Administrator.*

PROPOSED MINIMUM RATE INCREASES FOR 34 SHORTAGE CATEGORIES IN AERONAUTICAL RESEARCH, UNDER SECTION 803 OF THE CLASSIFICATION ACT OF 1949

On December 9, 1958, the National Aeronautics and Space Administration requested top of grade pay for scientists and engineers. This was a renewal of prior requests made by NACA. Supporting information presented on August 21, 1958, at the request of the Civil Service Commission, showed 583 estimated vacancies, of which 449 were in 34 shortage categories of aeronautical research scientists. Our current vacancies in these 34 categories total 425. Additional data concerning numbers on roll, losses, offers, and declinations, and the like were also submitted. These data are still generally correct. A serious decline in recent years was also noted in the percentage of better students accepting NASA employment, as shown on attachment A. This request was not approved.

Since that time our recruitment situation has steadily deteriorated. Despite intensive efforts we have been unable to attract a sufficient number of trained scientists from industry to staff key programs at the middle and higher grades because of salary deficiencies.

The NASA therefore has requested and received from the Civil Service Commission the names of approximately 3,000 scientists and engineers on various civil service registers in the United States as a possible additional source of personnel. We have written some 1,250 letters to those with a background which appeared suitable for our work. Of these, some 200, or 16 percent, submitted applications, and of these 5 people met our special experience requirements and were offered appointments. Only two of these accepted appointment. Although we will continue actively to explore such recruitment possibilities these registers have not been a reasonable source of personnel nor a reliable indication of the supply of talent for our programs.

Meanwhile NASA most urgently needs personnel of high quality to staff critical programs such as project Mercury. Of the 340 professional personnel required by this project, 186 have been brought in, a large number by transfer from other urgent NASA programs. As you know we are getting 32 scientists qualified in our work from Canada for this project, and these are included in the 186. There remain 154 positions for Project Mercury alone which must be filled immediately. In addition to our intensified national advertising program, we have recently taken a new approach in order to fulfill these requirements. Under this approach we are doing concentrated recruiting at all levels in cities with large scientific populations. In the last 2 weeks recruiting teams have visited Baltimore, Boston, and Atlanta. Each of these visits was publicized by 7-inch column ads in local newspapers run for 3 days. In Baltimore we attracted 15 interviews, in Boston 6 interviews, and in Atlanta 10 interviews. Of these 31 people, only 10 met our minimum qualifications, and all 10 were offered appointments. The discussions on pay reported by our recruiters make it problematic how many will accept.

In our college recruiting program our largest installation reports that declinations are high. The impressions of our recruiters on this program are not optimistic, although a full appraisal will not be available until it is too late to do anything about it.

Recent salary surveys, notably the 1958 survey of professional income of engineers, prepared by the Engineers' Joint Council, show a wide discrepancy between Federal rates and comparable industry rates. While exact comparisons at the higher grades cannot be made from this type of survey, a disparity of $895 per year between the Federal hiring rate for quality B.S. graduates (GS–7, $5,430), and the median salary of $6,325 for 1958 graduates in the aircraft manufacturing industry is indicative of the lag in Federal rates which underlies our recruiting difficulty.

Enclosed are a few examples of unsolicited letters recently received from applicants declining our offers because of salary (attachment B). Such letters are indicative of the recruitment crisis with which we are now faced.

The NASA has a large majority of the Federal positions in the 34 categories identified in departmental Circular 793, supplement 15. In view of our recruiting difficulties we believe that immediate action is both necessary and justified under section 803 of the Classification Act of 1949 to raise the minimum rates for these classes to the maximum scheduled rates at all grades.

Attachments:

A. Graph of quality of recruits.

B. Declinations of employment (five letters).

AERONAUTICAL RESEARCH SCIENTIST RECRUITING ABOVE THE MINIMUM REQUEST, MARCH 31, 1959

Additional information supplied to Civil Service Commission personnel in support of subject request

APRIL 16, 1959.

STATEMENT OF NASA NEEDS OF AERONAUTICAL RESEARCH POSITIONS IN FOREIGN COUNTRIES

NASA programs such as the worldwide minitrack network require aeronautical research positions in foreign countries in the categories specified in Departmental Circular 793, Supplement 15. These commitments and our rapidly expanding future requirements urgently require tht the rates for foreign positions in these categories be no less than within continental United States, in order that we may recruit and retain the highly qualified personnel necessary for these operations. Therefore, a top-of-grade increase for these positions is necessary as a part of our request of March 31, 1959.

Estimated costs of proposed increase in minimum rates for NASA Research scientists, April 16, 1959

(*a*) Personnel on duty	$94,110
(*b*) Personnel needed in next 12 months	570,390
	[1](6,942,050)
Total	664,500

[1] Total payroll cost of personnel needed.

Losses of aeronautical research scientists, period Oct. 1–Dec. 31, 1958 (NASA, except Beltsville Space Center figures not available)

Grade:	Number of losses	Grade:	Number of losses
GS–5	6	GS–15	1
GS–7	6		
GS–9	18	Total all grades	47
GS–11	8	Total staff	2,070
GS–12	6	Annual loss rate (percent)	9.1
GS–13	2		
GS–14	0		

NASA research scientists—Number of personnel on rolls as of Dec. 31, 1958

Grade:	Staff	Grade:	Staff
GS–5	86	GS–14	255
GS–7	112	GS–15	163
GS–9	278	GS–16	2
GS–11	302	Excepted	108
GS–12	404		
GS–13	469	Total	2,179

NASA scientific vacancies now and for next 12 months, as of Apr. 10, 1959

	Immediate needs	Needs for next 12 months	Total
GS–5			
GS–7	102	108	211
GS–9	67	97	164
GS–11	94	82	176
GS–12	80	60	140
GS–13	54	51	105
GS–14	23	19	42
GS–15	5	2	7
Total	425	420	845

Senator YOUNG. Any other questions?

Mr. LEHRER. No, sir.

Senator YOUNG. Dr. Glennan, will you proceed now, please? Have you anything to add, as to the personnel problem?

Dr. GLENNAN. I would add only one thing: I do believe that while we are able this year by reason, I think, of the glamour nature of our activity, and I hope it is because we have an imaginative program laid out, to attract these younger men, we still suffer, as I think any other technically oriented agency of Government does, at the very high levels, the upper grades, as contrasted with industry.

I don't know any solution to that at the moment. We have done reasonably well. We keep working at it and it seems to me to be a governmentwide problem. We have done, I think, reasonably well on this so far. Would you proceed, Mr. Siepert?

Mr. SIEPERT. I have nothing further to add except to be responsive to any questions that you may wish to raise on the increases that are involved here, either in personnel or money.

Senator YOUNG. Have you any questions, Senator Martin?

Senator MARTIN. No.

Senator YOUNG. Have you any questions, Senator Cannon?

Senator CANNON. No.

Mr. LEHRER. I have one question, Mr. Chairman.

It is noted that there is a rather substantial increase in travel expenses from 1958 to 1959 and from 1959 to 1960.

In 1959 travel is estimated at $1,212,500; in 1960 the estimate is $3,181,000.

Will you please explain the reason for this apparently large increase?

Mr. SIEPERT. May I answer this in general terms and then Mr. Ulmer will have some specific projects to give you. The basic reason for the difference in travel is that we are a quite different organization in terms of the mission we now carry out in this space area.

In the past when the NACA had its mission related to aeronautical research and development, there was travel between stations, domestic travel to tie in with the military and other research installations, but the international part of NACA travel was actually quite small. Even domestic travel was of a small order compared to what NASA must undertake when we take on a responsibility that ties in with many more agencies, many contractors throughout the country with whom we did not have business before, and many different countries and different sites.

You saw this morning some indication of the extent of our worldwide responsibilities in the tracking stations which are located around the globe. When it came to estimating what our 1960 travel needs would be, we took particular cognizance of the travel experience of the Vanguard group, which was transferred to us from the Navy Department. There was a group which started out from scratch to develop specifically an orbiting satellite, including the establishment of a network in other countries to track the satellite.

From that experience we have extrapolated a NASA travel estimate for similar travel activity in our kind of a program. This is the best way we know to estimate our travel requirements. That is why they are substantially higher than anything in our previous experience. Mr. Ulmer, you may want to add something further.

Mr. ULMER. As a guideline, Mr. Chairman, the NACA travel requirements averaged out somewhat less than $100 per year for many years.

Dr. DRYDEN. Per man.

Mr. ULMER. Per man per year. The Vanguard experience Mr. Siepert referred to came to something in the order of $2,800 per man per year. We have applied that factor for a portion of the NASA people that will be engaged in the type of activity similar to Vanguard, and have provided something similar to the NACA experience for the balance of the people.

The figure for 1960 comes out somewhat on the order of $330 per employee. Now admittedly we do not have a full year of operation and a full year of experience to support this estimate, but we feel it is a reasonable estimate within these two guidelines that we had to work with. Within another year we will be able to make a more accurate, more reasonable, estimate.

Senator YOUNG. Are there further questions on this? Will you proceed, Dr. Glennan.

Dr. GLENNAN. This I think, Mr. Chairman, completes our discussion except for the executive session and for discussion of some proposed causes which we have in the bill.

Senator YOUNG. Mr. Lehrer has a few overall questions to ask of Dr. Glennan. Proceed.

ADEQUACY OF FISCAL YEAR 1960 AUTHORIZATION REQUEST

Mr. LEHRER. Dr. Glennan, when you testified before this subcommittee in February on the 1959 supplemental request for $48,354,000, you indicated that while you did not agree with Mr. Roy Johnson that an additional supplemental appropriation was required for fiscal year 1959, you were reasonably certain that additional funds may be required for 1960.

We note that there have been a series of changes in the details underlying the program presented to the committee which is understandable, since you had an additional experience and additional time to perfect the budget estimates.

But we would like to get your current thinking on the question of a supplemental. Is the program and budget that you are presenting to us for 1960 enough in your judgment, or have you been limited in any reprograming that you did to stay within the initially prescribed figure?

Dr. GLENNAN. We have been limited to an extent, I think. On the other hand, I think what we have today, Mr. Lehrer, is a very much more sound program, a program that is attainable with a given sort of results that we ought to have in this first year of our operation.

There is this about it. There is now no slack in this budget at all. It is wholly possible that one could find a million dollars here or $3 million, some item of this sort which you could challenge and say well, let's do without that. But I can show you 10 items where that $1, or $2 or $3 million would ease what is going to be a bind as we go along.

I have discussed this matter with the people in the executive branch of the Bureau of the Budget and with the President himself.

In looking at our total projected program we have his assurance that if we are in difficulty in carrying out with urgency the program which we have thus far planned, I can come back and will go back through channels to request a supplemental in 1960. Whether this is going to be necessary is not yet clear, however.

Mr. LEHRER. Dr. Glennan, earlier today in pressing for approval of the one site which the House did not give you, you pleaded that action should be taken today, because if you had to wait until Congress reassembled in January you might not get it then or it might take some time.

Do you visualize that you will require any additional authorization between now and January or now and March?

Dr. GLENNAN. I am tempted to take the easiest way here and say it would be wonderful to have authorization for twice as much money as we have requested, even though we stay with our appropriation request, simply to give us freedom to move should that become necessary for any reason.

There may be a technological breakthrough or some other sound reason that would push us forward and that the Congress would want pushed just as much as we. I think, under the circumstances that I have described, however—the development of a program and the sound development of an organization—that we are in reasonable shape as we have presented this to you here.

Mr. LEHRER. Could you summarize for us briefly and then present details for the record, as to the changes that have been made to your programs as between those that you had supporting the total request of $485,300,000 in December and the programs as you have presented them to this committee today?

Dr. GLENNAN. I think, Mr. Lehrer, that some indication of this was given in my opening statement. The portion of the program which has been given more support, if you will, relatively speaking, is that of the development of new vehicles.

The reason for this is simple. We have found that the vehicles available to us are very much less than adequate for carrying on a program of research in space. We could perform the same sorts of experiments over and over again at very substantially higher costs than we think we will achieve in the course of the next year or two. But we have taken the planned route of attempting to develop a family of vehicles at as early a date as possible that will make it possible for both the military departments and ourselves to get on with putting more complicated, more sophisticated, and heavier payloads into space at an early date.

Now in doing this, we have stretched out, if you will, some portions of our program, in the field of space science. We have reduced the number of firings in this year and in 1960 and stretched those firings out into 1961.

I think when we go into executive session you will see that our firing schedules and firing rates are still very substantial. We have reduced by $3 million the amount that we had hoped to put into this contract research. We have reduced by perhaps a quarter some of the work in advanced technology. We have transferred that work into hardware in the development of the vehicles which are described as Scout, Vega, Centaur, and the Thor-Delta.

By the time that these vehicles—let me put it in terms of calendar years. By the end of 1961—I think our people have calculated on the program which is presently supported by this budget, and most of the vehicles which will be fired into 1961 are in this budget—we will have placed in orbit or into deep space programs double the weight that would have been possible had we not done this and gone forward with the development in this vehicle program.

We have tried to place first things first. These take manpower; these take money. There is a reasonable limit at which you can go to develop a program of this sort. Where you develop an organization of this sort, I think this is exactly what we have done. I will be glad to put the detail in the record if you wish.

Mr. LEHRER. Yes; we would appreciate that.

(The document referred to follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and development appropriation, program adjustments

	Fiscal year 1959			Fiscal year 1960		
	Original	Revised	Change	Original	Revised	Change
Aircraft, missile, and spacecraft research:						
Support of NASA plant	[1] $338,800	[1] $588,800	+$250,000	$16,670,000	$16,670,000	
Support of JPL plant	8,156,500	8,156,500		8,156,500	8,156,500	
Research contracts	[1] 5,500,000	[1] 3,000,000	−2,500,000	8,200,000	5,200,000	−$3,000,000
Scientific investigations in space:						
Sounding rockets	5,000,000	5,000,000		10,000,000	10,000,000	
Scientific satellites	44,000,000	23,252,000	−20,748,000	61,800,000	22,800,000	−39,000,000
Lunar probes	20,021,750	7,720,750	−12,301,000	24,043,500	7,140,000	−16,903,500
Deep-space probes	16,000,000	17,791,000	+1,791,000	22,500,000	6,803,500	−15,696,500
Vanguard program	25,541,282	25,541,282				
Satellite applications investigations:						
Meteorology	3,400,000	2,500,000	−900,000	15,000,000	10,800,000	−4,200,000
Communications	4,700,000	3,460,000	−1,240,000	13,000,000	4,700,000	−8,300,000
Space operations technology:						
Manned space flight	37,661,200	37,661,200		70,000,000	70,000,000	
Space rendezvous techniques				3,000,000	3,000,000	
Space propulsion technology:						
Solid propellant rockets	700,000	700,000		3,000,000	3,000,000	
High-energy propellant rockets	7,000,000	7,000,000		17,000,000	5,000,000	−12,000,000
1,000,000-pound-thrust, single-chamber engine	12,000,000	10,000,000	−2,000,000	30,200,000	30,200,000	
Nuclear rocket engines	8,500,000	4,500,000	−4,000,000	8,000,000	8,000,000	
Space engines	300,000	300,000		3,000,000	3,000,000	
Auxiliary power units	500,000	500,000		3,000,000	3,000,000	
Space systems technology:						
Advanced vehicle systems	500,000	500,000		1,500,000	1,500,000	
Booster recovery systems	500,000	500,000		1,500,000	1,500,000	
Orbiting space laboratories				2,000,000	2,000,000	
Supporting activities: Tracking and data acquisition	4,300,000	3,300,000	−1,000,000	11,500,000	11,500,000	
Vehicle development:						
Scout		6,048,000	+6,048,000		2,000,000	+2,000,000
Delta		13,800,000	+13,800,000		13,300,000	+13,300,000
Vega		22,800,000	+22,800,000		42,800,000	+42,800,000
Centaur					41,000,000	+41,000,000
Total, research and development	[1] 204,619,532	[1] 204,619,532		333,070,000	333,070,000	

[1] Does not include $11,137,302 for support of NASA plant and $1,000,000 for research contracts provided in the "Salaries and expenses" appropriation. The revised estimate for support of NASA plant on a basis comparable to the 1960 estimate is $11,726,102, while that for research contracts is $4,000,000.

FUTURE COSTS

Mr. LEHRER. In your testimony in the 1959 supplemental, you said, and I quote:

Today we are making the downpayments on programs that will inevitably cost very much more in the years ahead.

It would be appreciated if, in reviewing the record, you would insert after each of the various items covered in the detailed justification, wherever it is practicable to do so, the best estimates that you can make of either the costs that would be involved in 1961 and in 1962 or, in the case of some of the construction programs, the costs that you now foresee to complete the capital equipment for the projects involved.

In other words, as much information as you can give us as to future costs in this rapidly evolving field so that the committee will be able to point to the nature of the ultimate bill that will be involved in the very projects covered by this 1960 authorization.

Dr. GLENNAN. I will be glad to do that to the extent that it is possible to give you a rational figure.

DEVELOPMENT OF FISCAL YEAR 1960 BUDGET

(The following information was subsequently provided by NASA:)

The Administrator has testified that future budgets of the National Aeronautics and Space Administration would exceed the present budget currently before Congress, and might double or triple in amount over the next 3 or 4 years. This testimony is based on the assumption that the American people desire U.S. leadership in space exploration and aeronautical activities and the administration and Congress approve the funds requested. It does not take into account any major breakthrough in space or aeronautical technology which would reduce the necessary moneys to a corresponding degree.

Since most of the NASA's newer research and development activities will be accomplished through contract with nongovernmental institutions and resources, there is no present expectation of any major increase in NASA's personnel.

In research and development (without overrun) completion costs beyond fiscal year 1960, of new space engines and vehicles, are tentatively estimated as follows:

	Million
1,000,000-pound-thrust single-chamber engine	$61.70
Delta	10
Vega	26
Centaur	34

The level of activity and rate of progress in other areas of research and development make it impossible to estimate future costs at this time. Fairly substantial increases in basic and supporting research will be required to maintain a reasonable rate of progress.

However, in the space science flight program, after development of the newer vehicles, the estimates for the average cost per launching tentatively appear as follows:

	Million
Scout	$1.8
Delta	5.0
Vega	10.0
Centaur	13.0

These figures include the costs of the vehicle, payload, and launching.

As far as construction and equipment are concerned, the new responsibilities of the NASA will require some increase in construction of laboratories and testing equipment at the research centers. The scope of this increase cannot be determined at present.

In the tracking area, funds already requested from Congress will substantially complete the minitrack and optical networks. It is expected any moneys subsequently requested will be for modification equipment. Additional tracking apparatus for deep space probes will be required. The estimates are indeterminate as they depend on advances in the state of the art in communications equipment.

Additional tracking and range operations for Project Mercury will be necessary. The progress made in the program will make clear the additional sums required.

Mr. LEHRER. And could you also submit for the record a complete chronology covering the development of your fiscal year 1960 budget, starting from estimates submitted by the field installations, if that was the sequence, bringing it up to date?

Dr. DRYDEN. I think one point should be made. Since NASA did not come into existence until October 1—the budget was due September 30; it was submitted by NACA—it is obvious that it was not built up from field installation requests.

A preliminary estimate was submitted in the budget, and we will put all of the details into the record.

(The following information was subsequently submitted by NASA:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Chronological history of fiscal year 1960 budget

	Salaries and expenses	Research and development	Construction and equipment	Total
Preliminary and tentative estimates. (These estimates were prepared during late September and early October 1958, at the time the NASA was being organized and staffed. Portions of the preliminary estimates, particularly those relating to the operation of, and the construction of facilities at, the NACA laboratories taken over by NASA, were supported by detailed backup material. The balance of the estimates, particularly the amounts estimated under the R. & D. title were, of necessity preliminary and tentative in nature.) These estimates were prepared by top officials of NACA pending organization of NASA.	$93,000,000	$442,200,000	$90,000,000	$625,200,000
Revised estimates submitted to Bureau of the Budget. (By mid-November 1958, the Administrator and his staff had completed a thorough analysis and review of the preliminary budget and had coordinated the proposed amounts with the appropriate agencies of the Department of Defense. The results of these reviews culminated in the submission of an NASA budget request totaling $523,600,000.)	94,430,000	350,070,000	79,100,000	523,600,000
Amounts approved by the Bureau of the Budget for inclusion in President's budget (December 1958)	94,430,000	333,070,000	57,800,000	485,300,000

Mr. LEHRER. There is one further thing that would be helpful for the record. Would you indicate the firms, institutions, or agencies who are currently receiving contracts for the various projects for which funds were covered either in 1959 or 1960?

Dr. GLENNAN. That is no problem at all.

Mr. LEHRER. We recognize you cannot project who will get contracts in 1960.

Dr. GLENNAN. I will give you those that have been signed, of course.

(The information referred to is as follows:)

Report of research and development contracts over $25,000 awarded by NASA for the period Oct. 1, 1958, to Apr. 30, 1959

Contract No.	Name of contractor	Contract date	Description of work	Face amount of contract	Amount funded in fiscal year 1959	Estimated amount to be funded in fiscal year 1960
NASW-2	Catholic University, Washington, D.C	Oct. 15, 1958	Research investigation of high-strength materials	$27,500	$27,500	
NASW-3	University of Minnesota Institute of Technology, Minneapolis, Minn.	Oct. 21, 1958	Research investigation of Prandtl number and thermal conductivity of gases.	30,514	30,514	
NASW-4	University of Michigan Research Institute, Ann Arbor, Mich.	Oct. 27, 1958	Research investigation for measuring properties of upper atmosphere.	175,000	175,000	
NASW-5	The regents of the University of Michigan, Ann Arbor, Mich.	Nov. 12, 1958	Research on heat-resistant alloys	50,000	50,000	
NASW-6	California Institute of Technology (JPL), Pasadena, Calif.	May 1, 1959	Basic and applied engineering research and operation as directed by NASA.	(1)	22,300,000	$34,000,000
NASW-7	Instituto de Geofisico de Huancayo, Lima, Peru	Mar. 6, 1959	Radio tracking and receiving station near Ancon, Peru.	75,000	75,000	150,000
NASW-8	University of Denver, Denver, Colo	Nov. 20, 1958	Research investigation on properties of tungsten	49,815	49,815	
NASW-11	Bendix Radio Division, Bendix Aviation Corp., Baltimore, Md.	Apr. 24, 1959	Operation and maintenance of minitrack stations in Cuba and South America.	856,129	856,129	1,000,000
NASW-13	University of Virginia, Charlottesville, Va	Dec. 11, 1958	Research investigation of computer phenomena by high-velocity molecular beams.	34,200	34,200	
NASW-16	North American Aviation Corp., Rocketdyne Division, Los Angeles, Calif.	Jan. 9, 1959	Development of 1500K rocket engine	102,471,761	10,000,000	30,000,000
NASW-17	State University of Iowa, Iowa City, Iowa	Apr. 1, 1959	Reduction and analysis of radiation observations of satellites.	311,420	311,420	
NASW-19	University of Chile, Santiago, Chile	Mar. 12, 1959	Operation of earth satellite radio tracking and receiving stations.	76,800	76,800	153,600
NASW-24	University of Chicago, Chicago, Ill	Feb. 2, 1959	Design and develop instrument to measure composition and energy operation of primary cosmic radiation.	300,280	300,280	
NASW-25	Itek Corp., Boston, Mass	Feb. 11, 1959	Development instrumentation for study of upper atmosphere composition.	607,250	607,250	
NASW-28	Bell Aircraft Corp., Buffalo, N.Y	Mar. 2, 1959	Feasibility study of liquid fluorine-liquid hydrogen in rocket engines.	1,189,000	1,073,200	115,800
NASW-29	Callery Chemical Corp., Callery, Pa	do	Research investigation of use of boronhydrides and related compounds.	174,949	174,949	
NASW-30	General Electric Co., Cincinnati, Ohio	Mar. 18, 1959	Development of liquid propellent rocket engine, etc., for Vega project.	5,215,000	4,122,000	1,093,000
NASW-31	New York University, New York, N.Y	Apr. 1, 1959	Investigation of neutrons produced by cosmic radiation at high altitudes.	98,000	98,000	
NASW-33	Massachusetts Institute of Technology, Cambridge, Mass.	Mar. 20, 1959	Research investigation of satellite gravitational experiment.	50,000	50,000	
NASW-36	Aerojet General Corp., Azusa, Calif	Apr. 6, 1959	Fabrication and delivery of sounding rockets	659,200	659,200	
NASW-37	Massachusetts Institute of Technology, Cambridge, Mass.	Apr. 15, 1959	Design, develop, fabricate, test, and deliver a high-energy gamma-ray detection instrument.	68,000	68,000	

[1] As funded.

Report of research and development contracts over $25,000 awarded by NASA for the period Oct. 1, 1958, to Apr. 30, 1959—Continued

Contract No.	Name of contractor	Contract date	Description of work	Face amount of contract	Amount funded in fiscal year 1959	Estimated amount to be funded in fiscal year 1960
NASW-38	Douglas Aircraft Co., Inc., Santa Monica, Calif.	Apr. 1, 1959	Design, develop, fabricate, test, deliver, and launch 3-stage delta vehicles.	$24,067,500	$7,039,000	$10,200,000
NASW-45	Convair Astronautics, General Dynamics Corp., San Diego, Calif.	Mar. 1, 1959	Design, develop, fabricate, and launch 8 Vega vehicles.	33,497,880	7,500,000	14,400,000
NASW-54	The regents of the University of Michigan, Ann Arbor, Mich.	Apr. 30, 1959	Astronomical experiments in satellites	81,600	81,600	
NASW-55	The regents of the University of Michigan	Apr. 29, 1959	Measurement of ultraviolet solar emission spectrum.	76,000	76,000	
NASW-56	University of Minnesota, Minneapolis, Minn	Apr. 28, 1959	Development of instrumentation for 3 space probes.	74,951	74,951	
NASW-59	University of North Carolina, Chapel Hill, N.C	Apr. 29, 1959	Development of telescope to study cosmic radiation.	63,140	63,140	
NASW-60	Lockheed Missiles and Space Division, Sunnyvale, Calif.	Apr. 1, 1959	Feasibility study on solid propellent boosters	51,991	51,991	
NAS1-38	Sperry Gyroscope Corp., Division of Sperry Rand Corp., Great Neck, N.Y.	Nov. 17, 1958	Instrumentation and installation of systems in dynamic systems vehicle.	273,136	273,136	
NAS1-41	CDC Control Services, Inc., Hatboro, Pa	Nov. 6, 1958	Designing and furnishing surge control systems for hypersonic wind tunnel.	73,115	73,115	
NAS1-73	Electronic Associates, Inc., Long Branch, N.J	Dec. 2, 1958	OL-line data transmission systems	195,500	195,500	
NAS1-105	RCA Service Co., Division of Radio Corp. of America, Camden, N.J.	Jan. 29, 1959	Design services for range operation and control, Wallops Island, Va.	48,868	48,868	
NAS1-240	Space Electronics Corp., Glendale, Calif	Apr. 16, 1959	Design study of equipment for command control center station.	46,356	46,356	
NAS1-223	Electronic Associates, Inc., Long Branch, N.J	Apr. 23, 1959	Analog computing systems	430,000	430,000	
NAS1(w)-246.	Aerojet General Corp., Washington, D.C	Apr. 27, 1959	Design and construction of super Aerobee launching facility.	820,000	820,000	
NAS2-33	Arthur D. Little, Inc., Cambridge, Mass	Dec. 29, 1958	Design and fabrication of helium gas purifier for 12-inch hypersonic wind tunnel.	99,264	99,264	
NAS2-53	Cooper-Bessemer Corp., Mount Vernon, Ohio	Mar. 27, 1959	Helium evacuation compressor	164,710	164,710	
NA2-1444	Aerolab Development Co., Pasadena, Calif	Apr. 20, 1959	Design and fabrication heat transfer models	48,666	48,666	
NAS2-57	Beckman Instruments, Systems Division, Anaheim, Calif.	Apr. 3, 1959	Fabrication, delivery and installation of high-speed data recorder.	359,925	359,925	
NAS3-262	Douglas Aircraft Co., Inc., Santa Monica, Calif	Dec. 22, 1958	Febrication and delivery of propellant tank assemblies.	105,410	105,410	
NAS3-234	Solar Aircraft Co., San Diego, Calif	Apr. 1, 1959	Fabrication and delivery of rocket thrust chamber and special tooling.	181,835	181,835	
NAS3-305	Minneapolis Honeywell Regulator Co., Minneapolis, Minn.	do	Fabrication and delivery of automatic flight control systems of space capsule test vehicles.	152,728	152,728	

NAS3-386	Loewy-Hydropress Division, Baldwin-Lima-Hamilton Corp., New York, N.Y.	Apr. 23, 1959	Design and fabrication of 1,000-ton forging and extrusion press.	254, 575	254, 575	
NAS5-51	Aerolab Development Co., Pasadena, Calif	Oct. 3, 1958	Design and fabrication of booster hardware for TX-33 rocket motors.	69, 780	69, 780	
NAS5-59	McDonnell Aircraft Corp., St. Louis, Mo.	Feb. 13, 1959	Design and fabrication of manned satellite capsule.	19, 450, 000	10, 500, 000	8, 950, 000
NAS5-55	Thiokol Chemical Corp., Elkton, Md	Dec. 12, 1958	Fabrication and delivery of Recruit rocket motors.	108, 000	1080, 00	
NAS5-57	North American Aviation, Inc., Missile Division, Downey, Calif.	Mar. 17, 1959	Design, development, and furnishing rocket transport vehicles and launcher.	782, 278	782, 278	
NAS5-61	Minneapolis Honeywell Regulator Co., Minneapolis, Minn.	Feb. 11, 1959	Design, develop, test, and install attitude control system on orbital research vehicle.	770, 163	770, 163	

Senator STENNIS. I certainly thank Senator Young and the other members of the committee, Dr. Glennan and Dr. Dryden, and all, for carrying on. I am sorry I missed any part of your proof. I will get myself filled in in one way or another. I want to ask you this, Doctor: This morning, after inquiring if we wanted detailed proof on the installation items, you referred to them thereafter as a group.

Turn to your justification book, if you will. What did you include in that group that you have testified to? I believe you said there was several hundred million dollars.

Dr. GLENNAN. No, sir; it is on page 322, is it not?

Senator STENNIS. Well, I mean more than just——

Dr. GLENNAN. There was $57,800,000.

Senator STENNIS. I thought we were talking about more funds.

Dr. GLENNAN. No, sir. This is simply the pieces of equipment that are requested for our research centers in support of research activities going on.

Senator STENNIS. Your group statement then was limited to pages 322 and 323; is that all, sir? That is the entire amount of construction and equipment that was requested?

Dr. GLENNAN. Yes, sir.

Senator STENNIS. I thought that you had other items. I am very glad to have you answer that question. Have you covered the other items here on page 202?

Mr. LEHRER. Yes, sir.

Senator STENNIS. During the first phase of these hearings, Senator Cannon indicated that he would like to have your opinion concerning the effect of a 10 percent overall reduction in the funds you have requested for fiscal year 1960. Would you please supply such a statement for the record?

(The following information was supplied by NASA:)

As testified to in the hearings, the National Aeronautics and Space Administration has made a major decision, implemented by reprograming, to bring into development at the earliest date, the major new space engines and vehicles required for the exploration of space. The required research and development work on these vehicles is substantially involved in the funds requested for fiscal year 1960 by the NASA. In order to regain valuable time previously lost, the use of funds for these new vehicles deprived NASA of backup programs in its satellite and deep space launching schedule which is the insurance that research programs normally require. A reduction in funds requested where funds are already critical, would surely jeopardize the Nation's space program.

The dynamic nature of this new field of scientific effort at this early time in its development, has meant that estimates made in the first 2 months of NASA's operation as an agency have been more conservative than expected. The costs of new activities in space are greater per unit accomplishment, in early phases of the program, than had been expected. Thus, a cut of 10 percent or of any amount, must seriously affect and delay the Nation's program.

Senator STENNIS. Does anyone have anything to say now before we go into executive session?

Senator Martin, do you have a question?

Senator MARTIN. No, sir.

Senator STENNIS. Senator Cannon? All right, gentlemen. We will have to have an executive session now, please.

(Whereupon, at 3:30 p.m. the committee went into executive session.)

[Executive hearing as cleared by the National Aeronautics and Space Administration]

NASA AUTHORIZATION FOR FISCAL YEAR 1960

THURSDAY, MAY 21, 1959

U.S. SENATE,
NASA AUTHORIZATION SUBCOMMITTEE OF THE
COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES,
Washington, D.C.

The subcommittee met, pursuant to recess, at 3:35 p.m., in room 224, Old Senate Office Building, Senator John Stennis (chairman of the subcommittee) presiding.

Present: Senators Stennis, Cannon, Smith, and Martin.

Also present: Max Lehrer, assistant staff director, and Dr. Earl W. Lindveit, assistant chief clerk.

Senator STENNIS. All right, Doctor, will you proceed? We are in executive session.

FUTURE FIRING SCHEDULES

Dr. GLENNAN. I want to point out, Mr. Chairman, that this is not classified information in the ordinary sense of that term. What we are saying is we would like you to see how we are scheduling flights through 1961. As Dr. Dryden put it the other day in a House session, we don't get this sort of a schedule from the Russians.

We would dearly love to have such a schedule from them. We don't want to give them ours. And so we ask that this be kept administratively confidential here. But we want you to see the character of the activity and the frequency of these firings which are covered by this budget.

Senator STENNIS. I think we can say to the committee and the staff then that it is classified on the basis of honor and we will accept it as such. All right.

Mr. WYATT. This chart shows our tentative firing schedule in the categories except that of manned space flight, and I will later on show you a chart covering the manned-space-flight operation.

We break this down into three areas, our scientific program, the two applications areas, and then test vehicles. On this chart you probably cannot see where I have made some penciled corrections because the chart has been slightly revised.

I would like to call your attention to the fact as you undoubtedly know that there was a tentative probe at the planet Venus planned for June.

We found it necessary for technical reasons to postpone that shot. [Deleted.]

Now our other shots in here through the rest of this year include two more Vanguard firings. [Deleted.] These Vanguards will complete the series of the Vanguard-programed firings.

Then we have in here a number of the Juno II vehicles, some of which are carryovers from the original IGY ARPA orders, and five of which represent our last series of orders with ABMA. [Deleted.]

[Deleted.] This is similar to the Thor-Able, using the Thor first stage and the Vanguard second and third stages, but the Delta does include an upper stage guidance and it has structural modifications which will permit us to carry a much heavier payload than is possible with the Thor-Able.

You may recall the discussion of a large inflated sphere from which we will bounce radio signals.

This is the Atlas vehicle with a storable third stage.

Two of these are destined to be space probes. [Deleted.]

Now the third important vehicle—well, in here we have the Scout vehicles. These are the solid, four-stage solids that are being developed by the Langley Research Center. Actually at the moment we think that the Scout is going to be available before the dates shown here. [Deleted.] These will be fired from Wallops Island rather than from Cape Canaveral, and they represent a series of test vehicles. [Deleted.]

The last major vehicle that comes into play in this time period is the Centaur vehicle which is being transferred to the NASA as of July 1. It was started by ARPA.

[Deleted.] This is after what you might call our stretchout, our reprograming in order to get these higher weight capacity vehicles.

It still is a very heavy program. There are no light periods in that program.

Now this is only part of our total firing program. The remainder is shown here for the firings relative to Project Mercury or the man in space.

These fall into several categories. [Deleted.]

We will have a set of firings using the production Atlas and——

Senator STENNIS. Excuse me just a minute.

(Brief recess.)

Senator STENNIS. All right; pardon me for that interruption. Proceed.

Mr. WYATT. [Deleted.]

This is to confirm the design and to verify that the principles, construction and design principles, of the capsule are correct. They are full-scale capsules but they are not final flight capsules.

They are rather what we call battleship models, but they will confirm certain of the design principles. The "L" refers to what is called Little Joe. We call it Little Joe because it is such a little thing compared with the Atlas.

[Deleted.]

Now these capsules as indicated are not the final models, but they are hardware battleship simulation, that is rough simulation. [Deleted.]

Here we will start qualification flights of the actual capsule including its equipment. By qualification flight we mean we fire the cap-

sule with all of its gear in it and see if it does in fact work, if we can recover it, if all the components continue to work, and we will go through a series of flights with only instrumented capsules and some with animals in them, and we will actually check the physiological processes of the animals.

[Deleted.]

Then we come down to the Redstone boosters which we find convenient for training flights. [Deleted.]

Finally we come down to the orbital qualification. Down here is the first time we put the capsule itself on a complete orbit for one to three passes and then bring it back at direction, recover it, examine it. [Deleted.]

So we have all of these firings plus all of these firings. [Deleted.]

Dr. GLENNAN. All except one.

Mr. WYATT. Except one. We have this one flight out here.

Senator STENNIS. That is out in space itself?

Dr. GLENNAN. That is out in space itself.

Mr. WYATT. Out in time and space. But the two programs taken together give us a very heavy firing schedule for this time period of the next 2½ years. These are, of course, planning schedules. They are preliminary, tentative, whatever words you want. And there will be changes not just due to slippage but due to the many complexities of scheduling these in with competing projects.

Some of these we have to schedule against one another and we have to schedule them in with the Department of Defense projects as far as launching pad availablity goes.

Grossly this is our firing schedule for the next 2½ years.

Dr. GLENNAN. Thank you, Mr. Wyatt.

Senator STENNIS. Senator Martin, do you have some questions?

Senator Cannon?

Senator CANNON. Just one question, Mr. Wyatt.

Why are you using different boosters up there in that qualification series?

What is the point of using three or four different types of boosters?

Mr. WYATT. Because we can simulate different critical conditions that we want. For example, with the Redstone it is possible to get a condition which simulates the worst case, if in the flight program, the final flight program, the man has to what we call abort the flight after he is well up in the air.

This is when he hits his most critical reentry condition. He is almost up to full speed, doesn't quite make it, has to reenter. The Redstone works out technically to allow us to simulate that flight very well. Now the Little Joe and the Atlas similarly give us different ranges, different altitudes, and we can pick different parts of the final flight path, and simulate those parts of the path.

Dr. DRYDEN. Little Joe costs about a sixth as much as an Atlas.

Senator STENNIS. Are you through answering Senator Cannon? Senator Cannon, do you have anything else?

Senator CANNON. No, sir.

Senator STENNIS. Would you run over that briefly for Senator Smith. She was detained on other matters. Just Project Mercury and then summarize.

Senator Smith?

Senator STENNIS. I am sorry I was delayed on other business.

Senator STENNIS. I wanted you to see this.

Mr. WYATT. Project Mercury has phases of development. [Deleted.] Now these are not the actual flight capsules yet. This is a cabin in which the man rides. But they are full scale models that we actually build in our own shops that contain the principal elements. And we fire them at different conditions in order to verify the soundness of the design.

[Deleted.]

The capsules will be used over and over again. These are not one-shot affairs but we recover them, expect to have to do minor rework and then can use them again. So in here we also qualify these capsules with their full set of instruments, the life support system and so forth.

[Deleted.]

Then starting down in the training phase down in here, we again have some more animal flights and we begin to put man in to train the pilot. [Deleted.]

He will have a chance to get both physiologically and psychologically adjusted to this final orbital flight which will come down in this series of flights we call orbital qualifications.

These flights are to qualify the capsule, the whole system without a man in it, when we actually send it around the world from one to three times and call it in on command and recover it.

After we have demonstrated that we can recover this where we want to when we want to, and that everything is working so that a man can be supported, then some place out in here a man will go into the capsule and will go into the first manned orbital flight.

[Deleted.]

Senator STENNIS. One question before we leave your presentation. You spoke of the cancellation of the Venus shot.

Mr. WYATT. The postponement.

Senator STENNIS. Does that mean you will need less money for fiscal year 1960?

Mr. WYATT. No, sir. We are not saving any money. We are saving money indirectly with that. The shots were not at a technical point where for anything other than an attempt at prestige would it have paid us to shoot them.

We felt that the technical chances of completing the shots successfully fere not good and, rather than just shoot it because people would expect us to shoot it, we canceled.

But we will reuse those three vehicles as I explained.

[Deleted.]

Senator STENNIS. That question might come up somewhere and we ought to have it in the record.

Dr. DRYDEN. We don't like successful failures, and what happened was that in the ground tests that we asked the contractor to make, to investigate various questionable points, it became apparent that this would not be successful, that some further work had to be done.

Senator STENNIS. What is your next matter, sir?

PROPOSED LANGUAGE CHANGES

Dr. GLENNAN. I think then the only matter that remains is the language in the bill, and it may be you will want to go back into open session.

Senator STENNIS. I don't know that we should do that. I think we can go ahead in executive session. What is your comment now on the language?

Mr. NUNN. Mr. Chairman, the remarks that I have to make on the language of the bill are directed to the bill which we submitted on the 14th of April to both the House and the Senate.

Senator STENNIS. Let's see if every committee member now has the bill with the language proposals. The bill that was submitted to us is S. 1582. Is that the one you are talking about?

Mr. NUNN. I can speak to that, Mr. Chairman.

In so doing I want to bring out differences between that bill and the bill which the administration submitted.

Senator STENNIS. I think you should. Let's get before us now the bills in question.

Mr. LEHRER. This is the proposed bill to which Mr. Nunn refers, which was transmitted to the Congress more than a week after the committee had introduced S. 1582 in the Senate. It was therefore felt unnecessary to recall the bill and introduce a new one.

(The text of S. 1582, the letter transmitting the NASA proposed bill, and the text of the NASA proposed bill are as follows:)

[S. 1582, 86th Cong., 1st sess.]

A BILL To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) there is hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1960 the sum of $485,300,000, as follows:

(1) For "Salaries and expenses", $94,4330,000.

(2) For "Research and development", $333,070,000.

(3) For acquisition or condemnation of real property, for plant and facility acquisition, construction, or expansion, and for other items of a capital nature, $57,800,000, as follows:

(A) Langley Research Center, Hampton, Virginia: Alterations to thermal structures tunnel; analytical computing equipment; conversion of gust tunnel to noise research laboratory; conversion of test cells to noise test facility; and heater and vacuum system for gas dynamics laboratory, $4,580,000.

(B) Ames Research Center, Moffet Field, California: Data reduction center and mass transfer cooling and aerodynamics facility, $6,555,000.

(C) Lewis Research Center, Cleveland, Ohio: Ion and plasma jet facility; zero-power reactor; in-pile loop; and approximately twenty-five acres of land, $6,860,000.

(D) High-speed flight station, Edwards, California: Building additions, analog computing equipment; and terminal guidance facility, $2,805,000.

(E) Beltsville Space Center, Beltsville, Maryland: Central flight control and range operations building; space sciences laboratory; instrument construction and installation laboratory; and utility installations, $14,000,000.

(F) Pacific Missile Range, Point Arguello, California: Launching facilities, including flight vehicle assembly and check-out facility with equipment for special experiments, $3,000,000.

(G) Various locations: Global range tracking and communication facilities and equipment; facilities for Rover program; and propulsion development facilities, $20,000,000.

(b) Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (A), (B), (C), (D), (E), (F), or (G) of subsection (a)(3) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $57,800,000.

SEC. 2. Any amount, not to exceed $500,000, of the funds appropriated pursuant to authorization of subsection (a)(3) of the first section for the construction of facilities described under such subsection may, with the approval of the Bureau of the Budget, be used for the construction of new research facilities or for the modification of existing research facilities not specifically authorized in this Act, if such construction or modification is deemed by the Administrator of the National Aeronautics and Space Administration to be of greater urgency than the construction of any facility authorized by this Act: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction of new research facilities or the modification of existing research facilities: *Provided further*, That no such funds shall be used for the construction or modification of any facility if funds for such construction or modification have been previously denied by the Congress.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., April 15, 1959.

Hon. RICHARD M. NIXON,
Vice President of the United States,
U.S. Senate, Washington, D.C.

DEAR MR. VICE PRESIDENT: The National Aeronautics and Space Administration respectfully submits for your consideration a draft of proposed bill "To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes."

The purpose of the proposed legislation is to provide legislative authorization for the NASA's 1960 regular appropriations as approved by the Bureau of the Budget.

The NASA has been authorized by the Bureau of the Budget to submit this proposed legislation to the Congress. It is respectfully requested that it be introduced in the 86th Congress.

Sincerely,

T. KEITH GLENNAN, *Administrator.*

A BILL To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there are hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1960 (a) such sums as may be required for "Salaries and expenses" and for "Research and development," and (b) the sum of $57,800,000 for "Construction and equipment," as follows:

(1) Langley Research Center, Hampton, Virginia: Alterations to thermal structures tunnel; analytical computing equipment; conversion of gust tunnel to noise research laboratory; conversion of test cells to noise test facility; and heater and vacuum system for gas dynamics laboratory, $4,580,000.

(2) Ames Research Center, Moffett Field, California: Data reduction center and mass transfer cooling and aerodynamics facility, $6,555,000.

(3) Lewis Research Center, Cleveland, Ohio: Ion and plasma jet facility; zero-power reactor; in-pile loop; and approximately 25 acres of land, $6,860,000.

(4) High-Speed Flight Station, Edwards, California: Building additions; analog computing equipment; and terminal guidance facility, $2,805,000.

(5) Beltsville Space Center, Beltsville, Maryland: Central flight control and range operations building; space sciences laboratory; instrument construction and installation laboratory; and utility installations, $14,000,000.

(6) Pacific Missile Range, Point Arguello, California: Launching facilities, including flight vehicle assembly and check-out facility with equipment for special experiments, $3,000,000.

(7) Various locations: Global range tracking and communication facilities and equipment; facilities for Rover program; and propulsion development facilities, $20,000,000.

(c) Appropriations for "Research and development" may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts.

(d) When so specified in an appropriation act, any amount appropriated for "Research and development" and for "Construction and equipment" may remain available without fiscal year limitation.

SEC. 2. Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (1), (2), (3), (4), (5), (6), or (7) of section 1(b) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $57,800,000.

SEC. 3. Any amount, not to exceed $5,000,000, of the funds appropriated for "Construction and equipment" pursuant to this Act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering developments and if the Administrator determines that deferral until the next authorization act would be inconsistent with the interests of the Nation in aeronautical and space activities, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities, and equipment: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction, expansion, or modification including those real estate actions pertaining thereto: *Provided further*, That no such funds shall be used for such construction, expansion, or modification if authorization for such construction, expansion, or modification has been previously denied by the Congress; and additional appropriations are hereby authorized for purposes of this section in the amount of $5,000,000.

Senator STENNIS. Here is the text, then, that you want to testify from, plus the House amendment?

Mr. NUNN. Yes.

Senator STENNIS. I think everyone has it now. Proceed.

Mr. NUNN. The first section, section 1 (a) and (b), provides authorization for appropriations of funds in three categories: "Salary and expenses," "Research and development," and "Construction and equipment." A few general remarks with respect to those three categories might be in order.

The "Research and development" title is the one intended to comprehend all of the aeronautic and space activities of the Administration except those that are covered by the other two titles.

The "Salaries and expenses" appropriation provides funds for all employees, personnel, and supporting activities. The "Construction and equipment" appropriation provides funds for all of the real property items, construction, and major items of a capital nature for NASA's own installations.

With those three categories in mind, let's proceed to look at the bill as submitted, section by section.

Section 1(c) on page 2, is a new provision designed to eliminate difficulties which we have experienced in connection with research and development contracting. As you know, section 307(a) of the basic NASA Act withholds authorization for certain types of appro-

priations. It does not authorize appropriations for real property or for other items of a capital nature whose estimated cost exceeds $250,000. As a consequence, we have found ourselves in an inflexible position in relation to contractors with whom we do business. Let me explain this.

We are entering many new areas of research and development, new in relation to the activities of NACA. Hence, our contractual negotiations, using research and development appropriations, give rise to the need for various items of a capital nature, facilities and equipment, of one sort and another, the cost of which exceeds $250,000.

Now these facilities or items of a capital nature cannot be anticipated in time to permit their inclusion in an authorization bill. And yet their acquistion—or their construction or modification or whatever may be involved—is absolutely essential to the performance of the research and development contract.

Section 1(c) here would authorize the use of research and development funds for the acquisition, construction, or expansion of plant or facilities or other items of a capital nature, but only where needed in the performance of a research and development contract.

For example, in connection with developing a new vehicle or a new booster, it may be necessary to build a test stand—including site preparation, engineering, including construction of a blockhouse, other buildings, and fixtures, including the tall steel superstructure, and all the wiring and equipment, all the piping and tankage, and the acquisition and installation of all items of any kind necessary to make the facility operative. Now this might be done on public or private land using these funds under this authorization. However, of course, no land would be acquired, purchased, or otherwise acquired with research and development funds. The plant or facilities or the items of a capital nature might be more or less than $250,000, and they might be of a permanent or a temporary nature and located anywhere in the world.

The reason I go into this illustration is to explain what is intended by the language so that the committee will have a clear concept of it.

The important fact with respect to subparagraph (c) is that such use of research and development funds must be required for the performance of a research and development contract.

Senator STENNIS. Let me interrupt you right there. We have a rather strict rule in the military construction bill about authorization over in the Armed Services Committee, where I also serve. I know you are in an experimental field here and I don't want to draw the line too strictly, but you say items of a capital nature. That could include a great many things. You said a test stand; I want to know would that include a hangar? Sometimes we debate a day over whether or not we will include a hangar someplace and so forth. What is your comment on this?

Dr. DRYDEN. I think a concrete illustration, Mr. Chairman, might help. We had competition for a million-and-a-half-pound engine. The award, as you know, finally went to Rocketdyne. Now Rocketdyne owns a lot of facilities paid for by the Government at Santa Susanna, their own test stand.

They also make use of Government-owned facilities at the rocket station at Edwards Air Force Base. Now in order to carry on work

on this engine, they need to modify certain of the facilities at Santa Susanna; we worked out an agreement with the Air Force by which the Air Force made the facilities available.

But we can't expect the Air Force to put out money for their modification to do our contract. We could not foresee who the contractor was going to be in advance so that we could put in a line item.

We do find in this budget, I think, one or two such items that we foresaw. But, in committing our funds next year, we cannot tell in advance who the contractor is going to be, what he might need at his plant of a capital nature to carry on the work.

The bill prevents us from expending any amount greater than $250,000 without some form of authorization. But this is the situation in which we find ourselves.

Senator STENNIS. Do you have something further?

Mr. NUNN. I want to add to what Dr. Dryden said that the military is not similarly restrained. For instance, in the Air Force the "Aircraft, missiles, and related procurement" appropriation is available for the expansion of public and private plants.

Senator STENNIS. I didn't say procurement, now. I was talking about military construction.

Mr. NUNN. Let me say that there is no intent with respect to this subsection (c) to utilize these research and development funds for the purpose of building up the NASA plant or the NASA facilities or laboratories or installations.

Senator STENNIS. What kind of language assurances and restrictions could you give us there? I think we want to give you what you want, what you feel you need. But, at the same time, to keep from setting a bad precedent and to avoid unfavorable comparisons, with other policies in other committees, see if you can't work out some kind of restrictive language here that would still give you the leeway you need and that would protect us. Do you want a little time to do that?

Mr. NUNN. I would want some time. The idea that you have suggested is that some further restrictive language be devised.

Senator STENNIS. Yes, sir.

Mr. NUNN. I would like to suggest, Mr. Chairman, that, by rather full testimony on the language that we have suggested, we can shed a good deal of light on the meaning and the intent of it.

Senator STENNIS. I think so, too.

Mr. NUNN. I would like to pursue that, if we can.

Senator STENNIS. You can testify all you wish, but the way it strikes me I think we need something that is more restrictive than just "items of a capital nature other than the acquisition of land," because I think someone else might interpret that to mean anything except land.

Mr. NUNN. The test that we are relying on, sir, is items which may be "required for the performance of research and development contracts."

Senator STENNIS. How much is the sum you are asking authorization for now, for research and development contracts, sir?

Dr. GLENNAN. $333 million.

Senator STENNIS. That shows what a broad field you have there, $333 million. I think we will have to have some guidelines on that

language. I believe you can do it. I think you and Mr. Lehrer here can carry on from there and take care of our problem. All right; do you have anything further on the language?

Mr. NUNN. Proceeding to the next section of the bill, it is subsection (d). That provision is intended to eliminate any legal doubt that the funds in those two titles, "Research and development" and "Construction and equipment," are available without fiscal year limitation.

Senator STENNIS. Yes.

Mr. NUNN. A doubt might arise from the phrase "for the fiscal year 1960" in section 1(a).

Senator STENNIS. All right. Proceed.

Mr. NUNN. I refer then to section 2.

That is a fairly standard provision that NACA has been accustomed to and that appeared in the last authorization act for fiscal year 1959 the supplemental. There is no particular comment to be made with respect to it unless there are any questions.

Senator STENNIS. Section 2 agrees with accepted standards, I think. Unless there are questions, go ahead.

Mr. NUNN. I would refer then to section 3. This is a provision that will provide a kind of flexibility that is different from the kind of flexibility that is provided by section 2.

Under section 2, 5 percent of any one item authorized in the construction category may be added to that item, if taken away from some other item in the construction category.

In connection with section 3, the flexibility is expressed in dollars—not percent. The provision would permit NASA to use up to $5 million of funds appropriated for construction and equipment purposes, to construct, expand, or modify laboratories or installations on two grounds.

If the actions are found by the Administrator to be required by rapidly changing program needs, or by technological breakthroughs, and if a determination is made by the Administrator that deferral of the item until the next authorization act would not be in the national interest. Now this is, in a sense, reprograming flexibility.

It is subject also to the provision that, upon reaching a final decision, the committees would be notified.

Furthermore, this authority, this flexibility, would not—indeed, could not—be used in order to accomplish some item of construction which the Congress had previously denied.

Senator STENNIS. That would apply to your same construction and equipment, $57.8 million.

Mr. NUNN. That is correct; it applies to the $57.8 million, sir.

Senator STENNIS. A little less than 10 percent.

Dr. DRYDEN. The amount is determined by such considerations as these. This is roughly the cost of a test stand. If we got into a situation where for reasons that we had not foreseen we had to build a new test stand, it would take a sum of this order and magnitude to do it. It would not result in any increase in the total funds appropriated.

Senator STENNIS. While we are on this, then, are there any questions on section 3? This is in keeping, I think, with practices that have been congressionally approved in many bills.

Mr. NUNN. I should make it clear to the committee, to complete this comment with respect to section 3, that the very last clause of it states:

> Additional appropriations are hereby authorized for purposes of this section in the amount of $5 million.

This signifies that a second method of financing an unforeseen development that is deemed by the Administrator to be of an urgent character would be to return to the Congress, to the Appropriations Committees, and seek an appropriation to do whatever the unforeseen item calls for. This is, in effect, unfunded authorization. Naturally, before returning to the Congress or to the Appropriations Committees with such a request, the request would be approved by the Bureau of the Budget.

Senator STENNIS. What about that last clause now in section 3? It seems that you are asking for additional appropriations.

Mr. NUNN. Additional authorization, sir.

Dr. GLENNAN. This is an amount, Mr. Chairman, of $5 million which we would ask the authorization action on, but which could not be used unless we went back through the Bureau of the Budget in the executive branch and submitted to the Appropriations Committee a request for funds not in excess of $5 million.

In essence it is authorizing $5 million more than we have asked to be appropriated in order to give that flexibility. In the event that an emergency need might arise this might happen while Congress is out of session, we could get on with preparing our papers for action very early in the next session.

Senator STENNIS. You have a flexibility here as between projects. You could vary them up to 5 percent.

Dr. GLENNAN. That is right.

Senator STENNIS. Then you could come over into this other category and you would have another flexibility there?

Mr. NUNN. That is correct.

Senator STENNIS.—that you are authorized at least even though you don't have the money?

Dr. GLENNAN. That is quite right.

Senator STENNIS.—that you do have the authority to proceed.

Dr. GLENNAN. That is right.

Senator STENNIS.—to the extent of $5 million.

Dr. DRYDEN. This is suggested by the fact that this year it has taken 5 months to get the first supplemental authorization bill through.

This will permit us to go to the Appropriation Committee in January. This is the point.

Senator STENNIS. I think you are entitled to some flexibility, but on top of those we have mentioned now you are asking for this clause over here, clause C, "Any items of a capital nature" within this $330 million top. And that is where we want you to specify and point out a little more.

Dr. DRYDEN. Could we get some guidance on what is in your mind, sir. Certainly there is no reason why we should not be restricted from spending any of this to build up existing NASA installations. Is this what you have in mind?

Senator STENNIS. That is one thing. I think we could work out something on the language here with you gentlemen and Mr. Lehrer

within a few minutes maybe, but I don't believe it would serve any purpose in discussing it further now.

Do you have anything else on language you want to say?

Mr. NUNN. I have nothing more on that. That covers the bill that we submitted.

Senator STENNIS. All right; let's ask questions now. There is language in the bill here and then language that the House added. Did you want to make any comment on that or will you make any comment on the language added by the House? You might quote it first and then comment on it.

Dr. GLENNAN. Is that on the authorization?

Mr. LEHRER. Yes.

Dr. GLENNAN. I would make this comment. I believe this is with respect to the continuation of the authorization procedure.

Senator STENNIS. I understand that is one of the items on the question of the continuation of authorization. We have not discussed that around the table.

Dr. GLENNAN. I would like to make it very clear that we have I think very much appreciated the opportunity of spending time with all of you in having you understand more clearly what we are trying to do.

To a very considerable extent this sharpens up some of the things that we might slough over otherwise.

It is a fact I believe that there is tendency to be delayed in getting appropriations through as a result of this procedure. I would hope that we could always come before you and keep you fully informed.

I would hope that you would keep an open mind as time goes on as to the necessity for continuing and the desirability for continuing the authorization procedure as such.

We are not convinced one way or the other at the moment of this. I have used the term a good many times in these hearings we are a very new agency in terms of the kind of a responsibility that we have.

I think it has been helpful to us and I hope helpful to you to be able to tell you as fully as possible, as is evidenced by that fine document you have, of our program.

Dr. DRYDEN. I think the only thing that makes us a bit restive, Mr. Chairman, is the fact that this late in the session we have made no progress on appropriations either for supplemental 1959 or supplemental 1960. We can't tell whether a bill will be through by July 1. I haven't the slightest idea.

Now this is the only aspect of it that makes us a bit restive.

We certainly have not objected to the procedures of testifying as fully as you wish.

We are quite content in the early stages of our dealing with one another. We are not making any request of you one way or another on this matter.

We are leaving it to the Congress where there seems to be some difference of opinion. We are staying out of that for the time being.

Senator STENNIS. I think it is quite helpful to us to have you come here and discuss your program. I hope it has been helpful to you.

Dr. DRYDEN. Very helpful.

Senator STENNIS. We appreciate very much your attitude about it. We will discuss that around the table here and use our best judgment on it.

Senator Smith, do you have any questions now?

Senator SMITH. No, I think not, sir.

Senator STENNIS. Senator Cannon?

Senator CANNON. No, sir.

Senator STENNIS. Senator Martin?

Senator MARTIN. I would like to ask your opinion of the modifications made by the House on this authorization. Does it generally meet your——

Dr. GLENNAN. You mean on the total bill?

Senator MARTIN. Yes.

Dr. GLENNAN. The fact that they have deleted or taken out of our bill this $4,750,000 which we are asking and essentially pleading with you to put back in so that it will get back into conference, this we feel pretty strongly about, I am going to submit for the record as good a statement as I can give you on this. With respect to the authorization procedures, I believe they put into the bill a 5-year period on this.

What I am saying to you or tried to say a moment ago was that I hope you will keep an open mind on this and not bind us up forever.

Senator MARTIN. I just wanted a brief statement such as that to clarify this. All of the other action taken by the House——

Dr. GLENNAN. I don't think there is anything else that we have any quarrel with. Our purpose here, if I may state it very sincerely, is to try to work together with you. I think that there has been every evidence of great interest on your part. The real problem is how do we bring these two mutually interested groups together so that we can get on with the job you want us to do with expedition? When we do not have as yet even the $45 million that is necessary to push these two or three projects ahead, the tracking project and the Mercury project, for which we want to commit the funds. We actually must commit these funds before the end of the fiscal year, but we don't have them.

Senator STENNIS. Let me, for the record, read the language the House added on this proposition of authorization. I don't think it is in the record. The House added this section:

> Notwithstanding the provision of any other law, no appropriation may be made to the National Aeronautics and Space Administration for any period prior to July 30, 1965, unless previously authorized by legislation hereafter enacted by the Congress.

In other words, they put a 5-year period on it.

(Discussion off the record.)

Dr. GLENNAN. What we are talking about here in the context of a $333 million request for research and development funds can hardly be very much because, if we did divert very much of this money, we would not be getting on with the research and development work.

In one category there, there is, I believe, in the engine category, $30,200,000 for the million-and-a-half-pound, single-chamber engine.

It is possible that at the Santa Susanna location modifications to test stands or research and development facilities might run a million and a half dollars, might run as much as $5 million. To do that we would have to take it away from something else.

(Discussion off the record.)

Senator STENNIS. Back on the record here. With reference to the item that the House left out—that is the one that it modified because

there has not been an actual selection of the site—suppose you give us all the criteria you can, go as far as you can on that, and have it ready for us with any additions that you can make to us from now until the time of the conference will be very helpful if we put it back in.

Can you do that?

Off the record again, Mr. Reporter.

(Discussion off the record.)

Senator STENNIS. Mr. Lehrer, do you have a question on proposed language?

Mr. LEHRER. Mr. Nunn, in proposing subsection (b) you have indicated that NASA has a critical need to use research and development appropriations for items of a capital nature when they are required in connection with the performance of research and development contracts. I quote the language of your proposal:

(b) Appropriations for research and development may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts.

This committee feels, however, that there should be some limitation on the use of R. & D. funds for construction purposes. Therefore, would you comment upon the following limiting language which is proposed to be added to subsection (b):

Provided, That no more than 10 per centum of the funds appropriated for research and development pursuant to this Act may be used for such items of a capital nature: *Provided further*, That, whenever the estimated cost of such items of a capital nature exceeds $250,000 in connection with the performance of any one contract, the Administrator or his designee shall promptly notify the House Committee on Science and Astronautics and the Senate Committee on Aeronautical and Space Sciences of the nature, location, and estimated cost of such items.

Mr. NUNN. It appears to me that the notice proviso would not give rise to serious difficulties. However, I foresee that the 10-percent proviso would adversely affect the intended and necessary flexibility provided by section (b). In order to carry out its program with dispatch, NASA must have flexibility in its procurement operations and the committee, I am sure, recognizes that this is the purpose of the section. It appears also that a problem of meaning may arise under the proviso in connection with the phrase "items of a capital nature."

In other words, serious accounting and administrative difficulties may be caused by the first proviso. Let me explain.

The 10-percent provision would require that a limitation account be established on the books of the Treasury. Administrative procedures would have to be established by NASA to accumulate expenditures of the class intended so that they could be recorded against the limitation. Furthermore, additional administrative arrangements, particularly in the procurement processes, would have to be made to single out from every large and complicated development contract all the items of a capital nature not identified as such. Once this laborious detailed work of culling such items out of a contractor's proposal is done, then the items would have to be priced and recorded against the limitation account. Since the proposed provision contains no basis for distinguishing capital from noncapital items and since it makes no distinction between major and minor items of a capital nature, the administration of the provision would involve a burden of considerable magnitude.

The basic purpose of section (b) is to provide flexibility in procurement. I would suggest, therefore, that if the interest of the committee is basically concerned with maintaining a close surveillance over the construction of major facilities through the use of research and development appropriations, we should be able to provide for that without sacrificing the urgent interests of NASA. I would like to submit a substitute proposal after giving the matter further thought.

Mr. LEHRER. The record will be kept open for this purpose.

(Subsequently submitted for inclusion in the record:)

The following language is submitted by NASA as a substitute for the previously suggested proviso to section (b) of the fiscal year 1960 Authorization Act as passed by the House of Representatives.

Provided, That none of the funds appropriated for research and development pursuant to this Act may be used for construction of any major facility the estimated cost of which, including collateral equipment, exceeds $250,000, unless the Administrator or his designee notifies the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the nature, location, and estimated cost of such facility.

The new proviso focuses upon the construction of any major facility. This phrase is intended as most descriptive of the subject of the committee's interest in establishing a notification procedure. The phrase would refer to such things as buildings, unremovable fixtures, test stands, launching pads, blockhouses, industrial facilities, and real property improvements.

The new proviso specifies that the cost of a facility includes "collateral equipment" so that the committee will be assured that the notice given to it in every case will comprehend all of the costs allocable to the facility as a fully equipped unit or completed component.

Senator STENNIS. Since we have discussed the House action and since the bill passed by the House has been referred to this committee, a copy of H.R. 7007 will be inserted in the record at this point.

(H.R. 7007 is as follows:)

[H.R. 7007, 86th Cong., 1st sess.]

AN ACT To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) there are hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1960 the sum of $480,550,000, as follows:

(1) For "Salaries and expenses," $94,430,000.

(2) For "Research and development," $333,070,000.

(3) For "Construction and equipment," $53,050,000, as follows:

(A) Langley Research Center, Hampton, Virginia: Alterations to thermal structures tunnel; analytical computing equipment; conversion of gust tunnel to noise research laboratory; conversion of test cells to noise test facility; and heater and vacuum system for gas dynamics laboratory, $4,580,000.

(B) Ames Research Center, Moffett Field, California: Data reduction center and mass transfer cooling and aerodynamics facility, $6,555,000.

(C) Lewis Research Center, Cleveland, Ohio; Ion and plasma jet facility; zero-power reactor; in-pile loop; and approximately twenty-five acres of land, $6,860,000.

(D) High-speed flight station, Edwards, California: Building additions; analog computing equipment; and terminal guidance facility, $2,805,000.

(E) Beltsville Space Center, Beltsville, Maryland: Central flight control and range operations building; space sciences laboratory; instrument construction and installation laboratory; and utility installations, $14,000,000.

(F) Pacific Missile Range, Point Arguello, California: Launching facilities, including flight vehicle assembly and check-out facility with equipment for special experiments, $3,000,000.

(G) Various locations: Global range tracking and communication facilities and equipment; facilities for Rover program; and propulsion development facilities, $15,250,000: *Provided*, That the Administrator shall notify the House Committee on Science and Astronautics and the Senate Committee on Aeronautical and Space Sciences of the site selections before any such facilities are hereafter established.

(b) Appropriations for "Research and development" may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts.

(c) When so specified in an Appropriation Act, any amount appropriated for "Research and development" and for "Construction and equipment" may remain available without fiscal year limitation.

SEC. 2. Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (A), (B), (C), (D), (E), (F), or (G) of subsection (a)(3) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $53,050,000.

SEC. 3. Any amount, not to exceed $5,000,000, of the funds appropriated for "Construction and equipment" pursuant to this Act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering developments and if the Administrator determines that deferral until the next authorization Act would be inconsistent with the interests of the Nation in aeronautical and space activities, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities, and equipment: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction, expansion, or modification including those real estate actions pertaining thereto: *Provided further*, That no such funds shall be used for such construction, expansion, or modification if authorization for such construction, expansion, or modification has been previously denied by the Congress; and additional appropriations are hereby authorized for purposes of this section in the amount of $5,000,000.

SEC. 4. Notwithstanding the provisions of any other law, no appropriation may be made to the National Aeronautics and Space Administration for any period prior to July 30, 1965, unless previously authorized by legislation hereafter enacted by the Congress.

Passed the House of Representatives May 20, 1959.

Attest:

RALPH R. ROBERTS, *Clerk.*

Senator STENNIS. There may occur to the members of the committee or to the staff additional matters, and on request I am sure you will be glad to supply the answers and we will keep the record open to that effect.

Otherwise we certainly do thank all of you for coming in and for your fine attention.

Will the committee remain for just a few minutes? I have an item or two that I want to bring up.

(Whereupon, at 4:25 the hearing was adjourned.)